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PROFESSOR DR. ROBERT KOCH.

DR. KOCH'S DISCOVERIES.

IN our SUPPLEMENT No. 780, Dec. 13, 1890, we gave in full the text of Dr. Koch's recent additional communication on his remedy for tuberculosis, in which he explained its nature and physical characteristics, the method of using it, its effect on healthy subjects, its specific action on tubercular processes, its local and general reaction, diagnostic value, curative effect, action on tuberculous tissues, the treatment applied to lupus, to tuberculosis of the bones and joints, the treatment applied to phthisis, its effects, etc.

A recent number of the *Medical Record* contains a letter from one of its staff correspondents in Berlin, who gives the following:

The inoculations are made in all the public institutions at the present time, and the facilities for the reception of tubercular patients are constantly being increased. Of the European physicians who were attracted here by Koch's paper of November 13, most of them have returned, and American physicians are now arriving. Of those now here from the United States, I may mention Drs. Ernest, of Boston; Abbot, of Baltimore; H. P. Loomis, Lindsley, Einhorn, and Stearns, of New York; and Dr. Von Ruck, of Asheville, N. C. American patients are also arriving, but find it difficult to receive the care and treatment they seek, and some of them are returning home, preferring to wait until they can receive the treatment there.

I have visited many of the clinics, and desire to call particular attention to the exhibition of patients by Dr. Gerhardt, at the Charité, and his remarks made to physicians in connection therewith. Dr. Gerhardt spoke in particular of Koch's lymph as a specific in its action upon tubercular tissue, and mentioned its importance as a diagnostic means, equal to the demonstration of the tubercle bacillus, but, like it, not infallible. As to the therapeutic results, he said the time is altogether too short to form any opinion, and a year or two must elaspe before we can correctly appreciate its value in his cases. He called attention to the occasional occurrence of hæmoptysis after the injections as probably referable to the so-called stage of reaction, and counseled great circumspection, especially in considerably advanced cases. The reaction, he said, was by no means uniform. In some cases the fever might appear in a few hours, in others it occurred later, even as late as twenty-four hours, and in three cases which he showed it did not occur at all, although one patient had received five centigrammes.

Dr. Ewald has treated ninety cases at the Augusta Hospital since the first introduction of the method, and of the results thus far he says in most of them their condition has been ameliorated. There is a state of euphoria, a better state of subjective feelings, improved appetite, disappearance of night sweats, less cough, etc., but physical examinations of the chest show no changes, unless an increase of the moist sounds during the stage of reaction and subsequently. New features are constantly being observed and the cases differ greatly, not only in the degree and duration of the fever, but also in their statements as to headache, general malaise, nausea, and various other sensations. He also observed various exanthems, and one case typical with that of scarlatina.

A post mortem examination of a case with extensive lung disease, and intestinal tuberculosis, and far advanced in the disease, and who had received one injection shortly before he died, revealed nothing characteristic upon the tuberculous ulcerations in the intestine as due to the inoculation. In speaking of the method he pointed out the difference between the preventive inoculations of Jenner and Pasteur and the repressive effect upon an established tuberculosis by Koch's method

At the City Hospital, which has been designated as the central station for Koch's method, the director, Dr. Guttmann, has set apart ninety beds for cases to be treated by inoculations, and Dr. Koch comes there personally to witness the results. Very exact graphical records are kept, showing the various symptoms of the stage reaction and also of the number of tubercle bacilli in the expectoration, which is examined daily by Professor Ehrlich, who has taken charge of the bacteriological laboratory. There Director Guttmann de-

PROFESSOR DR. BERGMANN.

monstrates a great many cases daily, and his observations coincide with those of Professors Gerhardt and Ewald in every particular.

From all this it may be seen that the state of affairs concerning this work and its clinical features is simply that of gradual accumulation of experience and knowledge, and the opinion is here very general that visiting physicians will be able to learn and see much more three or four months hence than at the present time. Patients certainly should be discouraged from coming here, especially since in a very short time the treatment will be carried out in American institutions, but, above all, because nothing is as yet certain or settled as to the results.

In the *Deutsche Medicinische Wochenschrift* of December 4, the following new investigations on the influence of Koch's medium on tuberculosis are published:

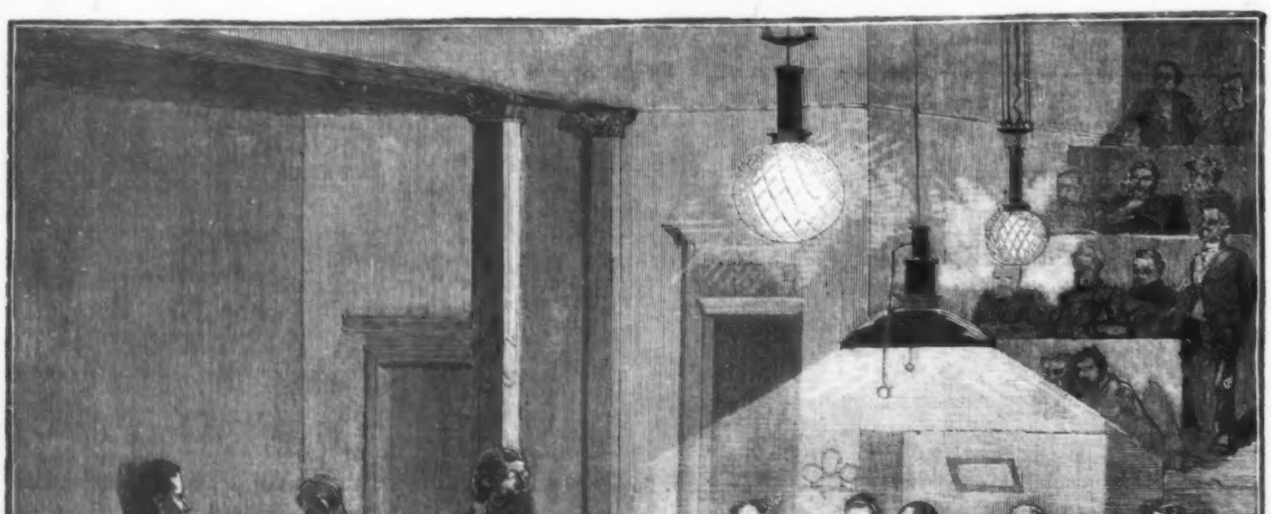
"Observations on the reactions which appear after the use of Koch's medium," by O. Rosenbach, of Breslau. Rosenbach advises the following classifications: (*a*) Suspicious cases, *e. g.*, catarrh of the apices, without bacilli in the sputum, and phthisical cases, *e. g.* vomici and old excavations and with bacilli. (*b*) With absence of bacilli but clinically of a phthisical nature. (c) Phthisical infiltrations with bacilli appearing during a long period of observation, but with either no fever or very slight fever. (*d*) Joint affections of a dubious character. (*e*) Clinically undoubtedly tubercular. (*f*) Affections of the bowels. (*g*) Affections of the larynx.

Having examined all these species, although necessarily but for a short period, Rosenbach arrives at the following conclusions: 1. It is always advisable to begin with small doses, namely, one milligramme, and if there be no reaction fever, to increase the dose by degrees. After the patients have become used to small doses they can be increased gradually, with longer intervals between each dose, and always with the greatest caution. 2. In phthisis of the larynx there was reaction in only one case. 3. The time at which the injection is administered has an influence on the febrile reaction, the temperature rises quicker and higher if the injection be made at the time when the fever usually comes on. 4. The injection is made by Pravaz's hypodermic syringe containing one cubic centimeter of Koch's fluid, which must be diluted with one-half per cent. solution of carbolic acid before the injection is made. The best place for making the injection is the cutis of the abdomen.

C. Von Noorden, of Berlin, Gerhardt's Klinik, has also written a paper on "Early Changes in the Lung under the Influence of Koch's Method of Treatment." A female patient, with lupus of the nose, was treated by Koch's method. The lungs and other organs were apparently in a normal condition. On November 21 the first injection was made of five milligrammes of Koch's fluid. In the evening the temperature rose to 38·8° C., the respirations were 42 and the pulse 110, the lupus spot on the nose became reddened and swollen, the commencement of ulceration became evident in the larynx, and the patient complained of pains in the right side of the chest. November 22: The fever continued; temperature, 39° C.; pulse, 122; respiration, 58. Over the lung there was exceedingly loud breathing. Expectoration, which had not existed before, now came on profusely and was of a muco-purulent character. There were no bacilli. November 23: Apices, anteriorly dullness and fine rales. Respiration, 30; temperature normal. November 24: Cough less, no expectoration. The dullness and rales were lessened. November 25: At 10 a. m. one centigramme was injected. At 3 p. m. there was chill, cough, and expectoration, temperature, 40° C.; pulse 132; respiration, 60; again dullness and rales. November 26: The patient was restless during the night; the temperature fell slowly to 38·8° C.; respiration, 68. In the morning, on the affected portion of the lung, bronchial breathing was found, with crepitant rales. The spot of lupus on the nose became again swollen, but not so much as after the first injection. November 27: The temperature fell to 36·5° C. and the respiration to 30. There was sweating and much dry cough. The condition of the lung remained as before, and there were no bacilli in the sputum. November 28 and 29: Showed a gradual decrease in the dullness. November 30: The dullness had nearly disappeared, and the breathing had become normal.

The author describes four more similar cases in which tuberculous spots could not be recognized by physical signs before the injection. After the injection they could be diagnosed by physical signs in the lungs. The affected part of the lung, after injection, became more infiltrated and thickened.

The time for the appearance of these changes varies twenty-four hours. After their appearance they usually begin to decrease. The author also warns against using Koch's remedy in cases where large portions of the lungs are affected, for by the thickening of the lung after the injection there is a diminution of



BERLIN—DR. KOCH'S METHOD BEFORE THE SURGICAL SOCIETY.

space for the air in the lung, which might become fatal in these advanced cases. These transitory infiltrations probably bring on the healing process.

Dr. E. Kromeyer, of Halle, examined portions of lupus tissue excised from a patient affected with that disease, and concludes that the injection brings on an inflammation of the structures surrounding the tubercle, wich results in suppuration of the same.

Professor Koch's Lymph.—The material used by Professor Koch in his inoculations for tuberculosis is a viscid fluid, the color of a dilute solution of iodine, is of a slightly sirupy consistence, and is supplied in white glass corked bottles containing each about forty grammes.

It is prepared for use by adding one hundred grammes of sterilized water, the maximum dose of injection being one gramme. The injection is made subcutaneously in any part of the body, but preferably between the scapulæ. No reaction appears locally, but at the end of four hours severe constitutional effects are manifest in the appearance of rigors with malaise, followed by a temperature which may reach 106° F., with a corresponding increase in the pulse-beat from 120 to 160. Vomiting frequently occurs at the acme of the fever. In some cases the reaction is attended with alarming symptoms, very great prostration, requiring the use of stimulants, and severe dyspnœa.

When the tuberculous deposit is superficial there is in and around it great tumefaction. The amount of constitutional disturbance is said to be governed by the extent of the tubercular deposit. This is noted particularly in cases of lupus and in tuberculous glands of the neck. The constitutional symptoms are usually of short duration. Subsequent injections are not attended with systematic disturbances. Over the surface and in the neighborhood of tuberculous swellings, scabs appear which, on being separated, leave healthy granulating surfaces. Cases in that stage are said to be cured, inasmuch as they show no constitutional reaction.

DR. KOCH'S REMEDY FOR TUBERCULOSIS—DR. BERGMANN SUPERINTENDING THE INJECTION OF THE LYMPH.

AN INTERVIEW WITH PROFESSOR KOCH.

BY DR. CHARLES HACKS, IN "L'ILLUSTRATION."

"My hour of consultation is between 12 and 1 o'clock," signed "Koch." This is written on a little square piece of paper fastened by four pins in a gray frame against the wall at the foot of the grand staircase in the entrance of the Imperial Hygienic Institute, in Berlin, and it was this that four European reporters were studying on the 5th of November, at 9 o'clock in the morning. Alas! what an illusion! Many others have been stopped by that little card, and gone no further. It is not easy, in fact, to reach this celebrated savant. From the porter to the secretaries, every one is extremely reserved in that house. It is almost impossible not to have one's card intercepted before it reaches its destination. We had the good fortune, nevertheless, to overcome all obstacles, and by exceptional favor obtained admission. We are going to try to lift a corner of the veil under which the German sphinx lies hidden, and to show to all the world the great question of the cure of consumption and by what intellectual and experimental processes the present condition of the science has been reached.

The intimate friend and adviser of Dr. Koch received us in his private study on the third floor of the institute. On the door is a little card on which are the words "Dr. Koch." The room is very small, and is partly filled by an enormous stove of faience, which reaches to the ceiling, and opposite to it is a large table covered with green and provided with two drawers. At the end of the room near the window is a little oak bureau, on which we perceived two proofs of photographs of which so much has been said, and which ought to be annexed to the report which is waited for with so much impatience. They represent two forearms with a hand showing the scars of tubercular lesions that have been cured, and photographs of which have been taken from day to day.

Prof. Koch immediately arose and stretched out his hand to me.

"I am very pleased to meet you," said he. "I remember very well our former intercourse at Marseilles at the time of the cholera in 1885. I remember also that you were the first one to translate my works and discoveries, but," and he held my card in his hand, "I guess the cause of your visit, and regret to say that I will not be able to tell you all I would like."

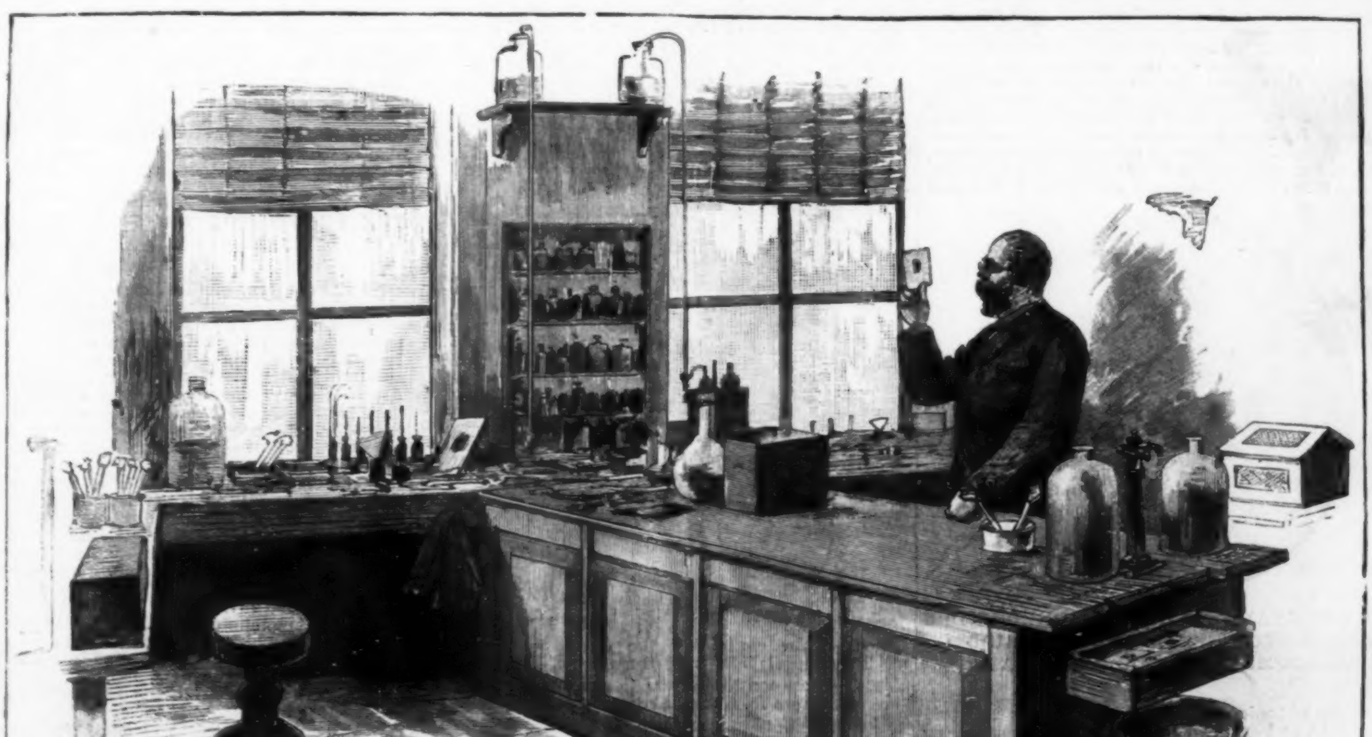
"Nevertheless," I replied, "the French public wish to know you, and to know and to see something of you and of what relates to your researches. That you will certainly grant me. In the first place, let me ask you for your photograph signed."

I then asked him for a tube containing some bacilli. Prof. Koch passed immediately into a neighboring room and came back holding in his hand a tube containing the *culture*, which he gave to me.

"Will you authorize me to say that these came directly from your laboratory and were given to me by you?"

"You know very well that I am a simple man, and how much I fear the notoriety which has arisen. Nevertheless, you desire it, and I give you the authority."

"Since you are in the vein, what would you think of letting me have a tube of the *culture* of comma bacilli of cholera? You are probably the only person in the



DR. KOCH AT WORK IN HIS LABORATORY.

world who has the germs of cholera bottled up, and it will be interesting to show as coming from the author of the discovery."

"It is not necessary for me to recommend to you the greatest prudence, as these bacilli are virulent."

"Certainly. I shall destroy them just as soon as I finish using them. I would like to give photographs of the laboratory."

"As you please. You can have what you wish except the small room at the rear. I am going to ask Dr. Pfeiffer to assist in making photographs of my laboratory of bacteriology, especially that part of it which relates to my work and where my experiments are made. He will give you all the information you need."

Dr. Koch was born December 11, 1843, at Clausthal, where he first attended school. From 1862 to 1866 he

FIG. 1.—THE BACILLI OF CONSUMPTION FROM NEW MUCUS EXAMINED UNDER THE MICROSCOPE.

studied medicine at Goettingen; then, having become a professor of medicine, he commenced his practice at Posen.

A few years later he was chosen professor and commenced his first work on the study of tuberculosis. He discovered the bacilli, he studied it, and settled the fact that consumption is caused by a bacillus. This work at once put him in the very first rank, so that in 1883 he was sent by the Prussian government to India to make a study of cholera and to discover the cause of that infectious malady. This time again success crowned his efforts, and it is admitted to-day without doubt that cholera is caused by comma bacilli (a name which Dr. Koch himself gave it on account of its resemblance to the comma), as tuberculosis is caused by the Koch bacilli. As a reward for his services, on his return the state voted him a purse of $25,000. The importance of the work of this German savant was thus recognized, and it appears that he is justly entitled to be considered one of the most extraordinary persons of our time. It may be well to mention at this point that according to Koch there is no fear of cholera returning to Europe, or at least it will not pass beyond some of the countries of the south. Berlin with its remarkable system of sewerage, and Paris also, have nothing to fear from that terrible malady. This is certainly reassuring. Thus it may be seen that the object of all of Professor Koch's work is the discovery of the cause of infectious diseases. He is satisfied that what he has done for tuberculosis and cholera, and what others have accomplished for other maladies that are less deadly, such as erysipelas, could also be done for all diseases, whatever they may be. From this it may be seen that his labor on behalf of science is not yet finished. It appears in fact that Koch has for the time being abandoned the examination of microbes for that of their destruction in the living human body. It is well known, thanks to him, that consumption is occasioned by microbes whose presence in the lungs, as, for example, in the case of pulmonary tuberculosis, occasions the phenomenon of phthisis. It is useless in treating this disease to repeat the errors of the past

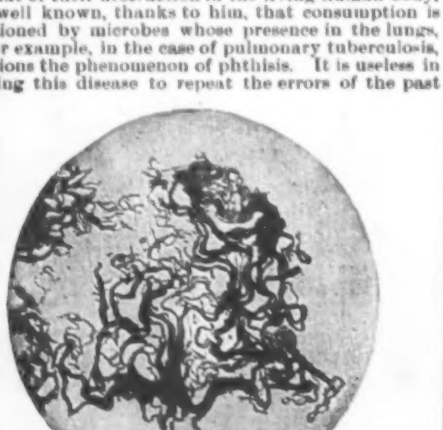


FIG. 2.—THE SAME BACILLI EXAMINED UNDER THE MICROSCOPE AFTER A PERIOD OF DEVELOPMENT OF FOURTEEN DAYS.

by the use of tonics and by telling patients to avoid taking cold, and even, when some new specific has been discovered, to force the patient to swallow it; all this and the use of a hygienic *régime* and certain remedies resorted to in the treatment of phthisis, have accomplished nothing, and patients continue to suffer and resist the disease a longer or shorter period of time. Dr. Koch abandoned this well beaten road, he threw aside everything which did not rest upon the solid scientific basis; all the experiments that had been made, from the benzoic acid to the hot air method, all that is an illusion, because it is based on a misconception.

Prof. Koch first commenced experiments with a tube which we represent. It is an ordinary test tube, such as is used in all ordinary experiments. It is, in the first place, sterilized over the fire, then a bouillon of sterilized *culture* is poured into it, that is to say, *culture* which does not contain any germ. This bouillon is prepared with agar-agar, a sort of gelatine. When this has been done the microbe, which is taken directly from the mucus of a consumptive, is placed in the tube and the orifice is closed with cotton, thereby permitting the air to pass into the vessel, but retaining the organisms, which are held suspended therein. The

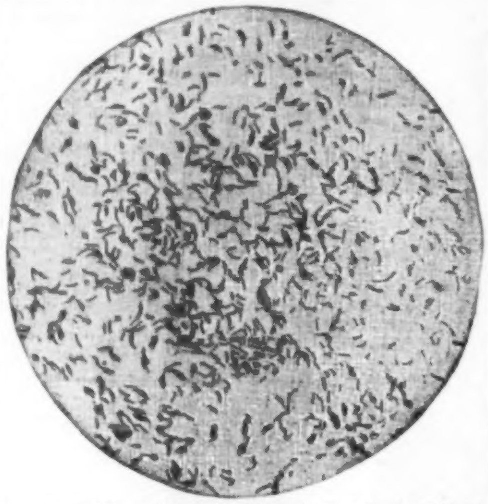


FIG. 3.—THE SIMPLE CULTURE OF BACILLI OF TUBERCULOSIS EXAMINED UNDER THE MICROSCOPE.

tube thus prepared is subjected to an even temperature in an oven. After a certain length of time the microbes begin to develop and increase, and assume the clotted appearance which we see in one of the engravings, and which is one of the characteristic peculiarities of consumption. But in order to experiment effectually it is necessary to have the *culture* absolutely pure, and it is obtained in this manner: In the first place take some of that treated as above and place it in another tube. This is repeated, and after 50 or 60 successive changes of this nature a residuum is obtained which is called pure *culture*, that is to say, it contains absolutely nothing but the microbe which it is desired to study. The pure *culture* of bacilli of tuberculosis is represented in the photograph which we have reproduced, Fig. 3, the negative of which came from the Koch laboratory. It gives perfectly the idea of what may be seen in the field of the microscope. Each one of the black points which are seen in the photograph represents a bacillus, that is, a pathogenic organism, which is the cause of the disease and which was discovered by Koch. It was upon these pure *cultures* that Koch made his first experiments, to try upon each one a long series of chemical reagents, of which the following are the principal: In the series of ethers, etherized oil; of the series of aromatics, *B* naphthaline, para-toluidine, xylidine, fuchsine; among the colors, gentian violet, methylene blue, China yellow, aniline yellow, orimene; of metals, tin, silver, and gold. He found the action upon the last of these the most energetic of all.

It only required one or two millionths of chloro-cyanide of gold to stop all development of bacilli of tuberculosis in pure *culture*. It is seen what an enormous amount of time and trouble was required to make all these tests. Koch saw not only that all the substances

FIG. 5.

FIG. 6.

FIG. 5.—Tube containing the Germs of Bacilli of Tuberculosis from the Laboratory of Dr. Koch.

FIG. 6.—Tube containing the Germs of Comma-bacilli of Cholera from the Laboratory of Dr. Koch.

which we have cited, but many others with which he experimented—a list which would be too long for us to give—have the power in a test tube of arresting the development of bacilli of consumption. He had, therefore, finished the first part of his programme in searching for the substances which when mixed with pure *culture* of bacilli of tuberculosis were able to arrest their development. He passed on then to the second part of the programme, viz., experiments upon animals. He selected the guinea pig as a subject, because of all animals this is the most liable to tuberculosis when inoculated. He tried all the substances mentioned in the above list upon the guinea pig thus rendered consumptive, and he observed that although the action of these substances was so remarkable in the test tube, there was no apparent result when they were applied to the animal. All the inoculated guinea pigs died of consumption. Without being discouraged, however, he undertook a second series of experiments, also upon living animals. He succeeded in discovering a substance (and it is here that the secret begins) which, active in the test tube, preserves its action when it is transferred to the body of the animal. Upon the second series of guinea pigs which had been inoculated, the increase of the bacilli was stopped as soon as the substance was administered, and all were cured. Here it is necessary to rectify an error which the journals have spread. It is known that he made his experiments upon a large number of animals, and every day one of this number disappeared, and it was supposed that it was one of those that had been inoculated. No; it was simply that he killed one from day to day because he wished to follow all the stages that were reached. In all the autopsies it was found that the leison was stopped as soon as the substance was injected, no matter what stage of development the disease had reached. He was, therefore, able to let a certain number of ex-consumptives live, and they are to-day in a perfect state of health.

It was after these two series of investigations, which were so long, that having arrived at a definite result, he was enabled, before the Congress of Physicians held in Berlin in August last, to make his first communication, which caused so remarkable a sensation. This is what he said in concluding his remarks: "My researches are not yet entirely finished, and I am only able to affirm one thing, viz., that the guinea pig, which is, as every one knows, liable to consumption, became entirely free from it the moment that it had absorbed this substance, and from that moment the disease was arrested and its progress stopped, whatever may have been the stage previously reached, and that also without the constitution being in any way impaired. I am only able to draw one conclusion from these researches, viz., the possibility which exists from this day of paralyzing absolutely the action of the microbes in the animal. It is a new field open to experiment and observation." These were exactly, word for word, the conclusions of Dr. Koch in the month of August last, and it is on a false interpretation, or rather on a premature conclusion, that the idea was created at that time that his researches had attained to the cure of consumption in the case of man. Dr. Koch had not even made allusions to this. It was only later, and following always the idea and the scientific methods which have always guided Dr. Koch, that he began to experiment upon man, guided by the definite results already obtained upon animals and with a feeling of certainty that like results would follow.

With a simple Pravaz syringe and drops of the liquid the consumption disappears and the hectic flush is modified; the patient is cured; and if Dr. Koch is not yet willing to divulge his secret, it is because he is wise in his own opinion, founded on scientific principles, and that he is not willing to leave one iota of error. He was able to kill and to examine his guinea pigs when he wished to know the degree of advance in their cure; but he cannot follow the same course with men. He is no longer experimenting, he is curing. He is obliged to wait until his cure is complete and absolute. When the last of his patients is a well man, he will speak and we shall know all. Before then he will say nothing. This is the cause of his delay in satisfying a public curious and anxious to know all. These are the sorts of discoveries that open the infinite horizons of science and elevate to the highest pinnacle the one who has conducted the experiments; and one is compelled to respect the true savant, who fears notoriety, and who will quietly and modestly bestow, some day, this cure upon humanity, without any recompense (in spite of offers of all kinds, which come to him from every side), without any other profit than adding one more leaf to the already beautiful crown of that modern science of which the French genius, in the person of the great Pasteur, has furnished the elements, founded the principles, and brought about such magnificent results. For our illustrations we are indebted to *L'Illustration* and *Le Monde Illustre*.

THE PROTECTION FROM DIPHTHERIA AND TETANUS BY INOCULATION.

Berlin, December 4.

BY the courtesy of the *Deutsche Medicinische Wochenschrift* your correspondent has received advanced proofs of an article on the prevention of diphtheria and tetanus in animals, based upon experiments in the Hygienic Institute, at Berlin, made by Dr. Behring, assistant in the institute, and Dr. Katasato, of Tokio. After long experimentation these observers claim to have cured animals suffering from either of these diseases—diphtheria and tetanus—by the inoculation of the serum from the blood of animals already infected. It is claimed by a large number of experiments, first, that the blood of rabbits protected from tetanus possesses the property of destroying the tetanus poison. Second, that this property is possessed by the noncellular serum obtained from the blood. Third, that this property is of so constant a nature that it also remains active in the organism of other animals, so that notable therapeutic effects are produced by the transfusion of blood or serum. Fourth, the property of destroying the tetanus virus is absent in the blood of those animals which are not protected against tetanus, and if the tetanus virus is injected into non-protected animals, it can be so demonstrated, even after the death of the animals, in the blood and in the other fluids of the body.

In the test of the degree of immunity a rabbit previously protected received 10 c.c. of a germ containing virulent tetanus bacilli culture, of which five tenths c. c. sufficed to make a normal rabbit yield inevitably to tetanus. The protected rabbit remained entirely healthy. He had not alone secured immunity against infection with living tetanus bacilli, but also against the tetanus virus, as he tolerated twenty times the amount of a poison which suffices to kill, without exception, normal rabbits.

Blood was taken from the carotid artery of this rabbit. From this fluid blood (before coagulation) two tenths c.c. were injected in the abdominal cavity of

one mouse, five tenths in that of another mouse. At the end of twenty-four hours both animals, together with two mice, were injected with virulent tetanus bacilli, and to such an extent that they were attacked by tetanus twenty hours afterward, and died in thirty-six hours. On the other hand, both previously treated mice remained permanently healthy. The larger amount of blood was allowed to stand until serum had formed abundantly, and of this serum six mice received each an injection of two tenths c. c. into the abdominal cavity. After the infection, which occurred twenty-four hours later, all six animals remained healthy, while the unprotected mice died of tetanus in less than forty-eight hours. Therapeutic results may also be secured by the serum in the following manner:

The animals are first infected by inoculation, and then the serum is injected into the abdominal cavity. Experiments with the serum were also made tending to show its great virus-destroying property. Of a ten days' tetanus culture, which had been made free of germs by filtration, 0·00005 c. c. sufficed to kill a mouse at the end of four to six days, and 0·0001 c. c. to kill in less than two days.

Now, we mixed 0·0001 c. c. of this culture and allowed the serum to act twenty-four hours upon the tetanus virus contained in the culture. Of this mixture, four mice received each 2 c. c. up to 0·033 c. c., or more than three hundred times the dose otherwise fatal to mice. Four mice remained permanently healthy, while the unprotected mice died at the end of thirty-six hours from 0·0001 c. c. of the culture. The mice, in all the hitherto mentioned series of experiments, both those into whom abdominal cavity serum was injected and those who were injected with a mixture of tetanus virus and serum, have remained permanently protected. They resisted subsequently repeated inoculations with virulent tetanus bacilli. This fact is especially noteworthy because in the innumerable individual experiments no mouse, no rabbit, in fact, no animal hitherto tested, had been found protected, and because the very long-continued attempts in the Hygienic Institute to make animals safe against tetanus by the hitherto known methods have been entirely unsuccessful.

The authors claim that they are justified in drawing the conclusion that the above expressed interpretation of the occurrence of immunity, which at once and without any difficulty shows a positively effective and for the animals entirely innocuous method of producing immunity, also satisfied the need of preventing its causation. As a matter of course, experiments were also made with the blood and serum of non-immune rabbits. This blood and serum proved therapeutically, as well as prophylactically, to have no influence upon the tetanus virus. This was also true of cow, calf, horse and sheep serum, as was shown by special experiments.

The blood within the vessels of living non-protected animals also possesses no tetanus-destroying properies as appeared from the following experiment, which was repeatedly made:

Animals who received a subcutaneous injection of 0·5 c. c. of a virulent tetanus culture, free from germs, died after five to six days with typical symptoms of tetanus. At the autopsy, in almost every case, a serious transudation is found in the pleural cavity. Of this transudation 0·3 c. c. on the average suffices to produce tetanus in a mouse, and to kill the animal, and in the same dose the blood of a tetanus-poisoned animal again produces tetanus in mice. In conclusion, the authors express a hope that the principles demonstrated in these experiments may in time be applied to the treatment of diphtheria and tetanus in man.—*Medical Record.*

THE MOJAVE INDIAN LITTER.

By CHARLES ALBERT SEWALL, M.D., Acting Assistant Surgeon, U. S. A.

WHILE serving at Fort Mojave, A. T., in 1888, I had a wounded Indian, "a Mojave," brought to me for treatment. The patient had his whole arm and forearm shattered by the accidental discharge of a shot gun. I found it necessary to amputate the limb at the shoulder joint.

The wounded man had been brought over seventeen miles, and his remarkably good condition and the comfortable manner in which the "Indian" Mojaves had taken care of him called my attention particularly to their peculiar and ingenious method of transportation.

In looking over some of the literature of this subject I have been unable to find anything exactly like it. The materials are always at hand and the contrivance is simple and comfortable not only to the patient but for the litter bearers. It is so much easier to carry a load for a distance on the shoulders than by the arms stretched at full length, as they are while carrying the two-handled litter.

The country in the Colorado River bottom, in Arizona, is exceedingly hot in summer, and at the time of year when the man was wounded, the average day and night temperature was 110° F. in the shade.

The comrades of the wounded Indian had exercised much care in his removal over a long, arid, hot river bottom country. They had gotten a wagon sheet of canvas somewhere and a long cottonwood pole; the canvas was loosely tied at the ends, just as one would tie a sling around the neck for a wounded arm, and the pole was slipped under the loosely tied ends, so that when his brother Indians stood erect with the ends of the pole on their shoulders, the canvas bag where the wounded Indian was lying was about from two to four feet from the ground. I tried their palanquin-like arrangement by getting in it myself, and found it to be comfortable and pleasant to ride in.

In this instance, where the wounded part was an upper extremity, the slightly flexed position of the body of the patient secured an easy way of riding.

It will be found in Stanley's "Through the Dark Continent," that some of his itineraries were made in a cot or hammock-like arrangement, carried on a pole, but nothing exactly like the above has ever before been shown, to the best of my knowledge.

The materials are as follows: First, a pole about ten feet long, of sufficient stoutness to carry the weight of a man; the pole may be taken from a fence, or a sapling may be cut for this purpose, and must be moderately smooth, stout, and strong.

Second, a piece of canvas, stout muslin, or an army blanket. This part of the apparatus may be anywhere from 5 by 5 feet, or less, up to 12 by 11; or if it be slightly greater or less in size it does not matter.

In the third place, the cloth, muslin, blanket, or canvas has to be secured to the pole near its ends, leaving just room enough for two men to carry the pole on their shoulders by its extreme ends, and the patient is placed at full length in the bag formed by this sling.

The method of securing the ends of the canvas, cloth, muslin, or blanket to the ends of the pole deserves consideration. In the case of canvas the Indians I noticed simply tied a loose "granny" knot at the ends, and slipped the pole under, and when the pole was lifted up by the bearer, the bag was formed.

This plan I have adopted in all cases where the material is susceptible of being tied, and will lie in a flat knot.

It has been suggested to me by Brevet Major-General Eugene A. Carr, U. S. A., that blankets, as an easily available material, would be a fine thing to use for the army in the field, and a device suggested by Major Washington Matthews, Surgeon, U. S. A., by which the blanket is secured to the pole at the ends, I have found to answer most admirably. In each corner of the government blanket, an ordinary gray one, a stone about the size of a lemon is secured by a stout sling or cord, firmly binding it in place, and the corners of the ends of the blanket are fastened together; the pole is then slipped under, and when lifted up by the litter bearers it will be found to be secure and all danger of slipping avoided.

In order to obviate a tendency to slip toward the middle of the pole, which will occasionally be observed, it may be found necessary to drive a small nail on the inside of where the knot or tie comes, or a notch may have to be cut in the pole with a penknife.

The canvas has been found by experience to slip toward the center much less often than the blanket arrangement.

Fort Wingate, N. M. —*Medical Record.*

IMPROVED DRAIN PIPE.

By GEO. E. WARING, Jr.

MR. NORMAN SHAW, one of the leading architects of London, who made a very early contribution to the improvement of house drains by a new form of disconnection outside of the house, has, within a few years past, suggested an improvement in underground house drains to which it seems well worth while to call attention.

All who are familiar with the difficulty of making tight joints with the earthern ware pipes now used, and with the difficulties that architects and engineers experience in their efforts to get good work done in this direction, and architects and engineers themselves who are conscious of their lack of certainty as to the character of this work, whatever care they may have given it, will readily understand the force and bearing of the objections to the method in use.

Vitrified pipes constitute the best material that we now have for continuing the drain beyond the point at which the iron pipe stops outside of the foundation wall, and if we could make sure that every joint was perfectly tight all around—free from cracks and free from leaks caused by the inflow of ground water—and that there was no rough intrusion of cement into the interior of the pipe, we need ask nothing more. Unfortunately, these are constant points of weakness and danger. The contractor's workman is often, if not generally, hurried and careless in his manner of doing the work. He does not himself know, because he cannot see, that the under part of the joint is all that it should be. He can judge of it only by feeling it with his fingers. Even though he leaves it quite tight, there is no certainty that, before the cement has set, ground water will not wash it away and find entrance into the pipe, leaving a permanent leak. The condition of the interior of the joint no one can determine. Even in its best condition, there is an unfilled groove which may catch sticks, etc., and ultimately cause an obstruction.

Mr. Shaw's purpose was to avoid these dangers. He describes his device in a communication to the *Builder* (London) of June 30, 1888, accompanying his description with a sketch showing his method. I submit both sketch and letter in the belief that you will consider them sufficiently interesting to your readers to reproduce them:

A NEW FORM OF DRAIN PIPE.

Sir: Among the many difficulties that we poor architects have daily to contend with in our practice, I think there are none more serious than drains. They present themselves in all our works, so we have always to face them; and when it is considered what terrible troubles may and often do arise from any defects in laying, I may be excused for calling the trouble a serious one. Yet this is one of the parts of our duty in which our personal superintendence is not only very limited, but may be said to be almost impossible; for how can an architect say that he *knows* the drains in any of his works are perfectly laid? He may have taken every possible precaution; he may have employed the best of materials and tried men; and yet, in spite of all his care, defects may exist, arising, as I venture to suggest, from requirements totally beyond the power of the architect to control. To secure a perfect drain it is necessary that all the joints should be absolutely sound, but men are required to lay drain pipes often at the bottom of a deep trench, in a position where they can neither see nor feel what they are doing. Is it wonderful if, under the circumstances, the joints of drain pipes are often found to be defective, and that occasionally some lengths are found to be laid either flat or with a fall the wrong way?

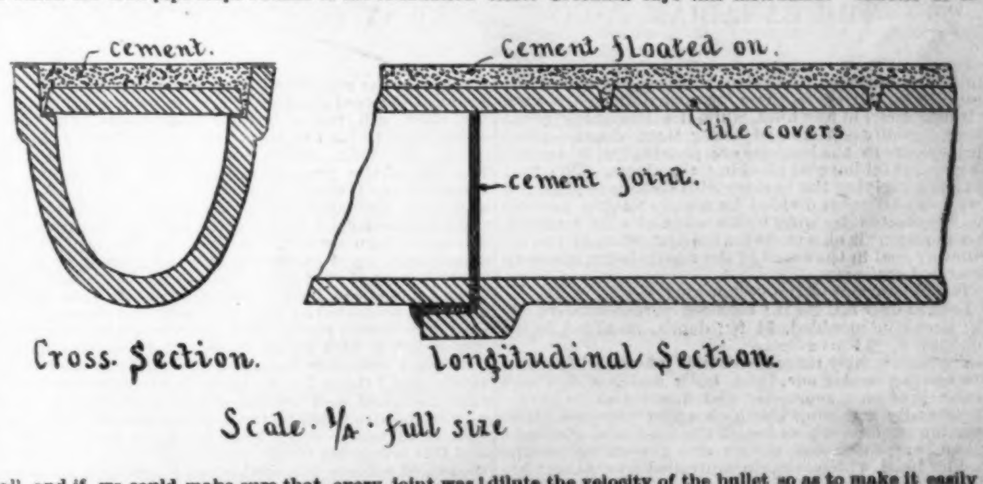
I beg to lay before your readers a new form of drain pipe, which I venture to believe will obviate all these difficulties. Instead of the ordinary socket-jointed circular pipes, I use a culvert of an egg-shaped section, open all along the top, with a rebated flange to receive covers. About the laying of these covers there is no difficulty of any kind, and when laid they can be inspected from end to end, each joint examined, and the uniformity of the fall tested to the utmost nicety. Should an imperfectly laid culvert be detected, it is easily taken out and another put in its place. (We all know the difficulty of getting out a defective socket-jointed pipe, and the bungling mess that ensues when this is necessary). When the culverts are found to be all well laid, and when the whole has been examined, the loose covers are laid in and pointed with cement, and then the whole pointed over with Portland cement as shown in sketches. It will be seen at a glance that a perfect drain has been made of the best possible section, and with the least possible trouble. If at any time a drain requires examination, it is at least as easy a thing to cut through the cement bed and chip out a covering tile as to cut a hole in a drain-pipe, as we now have to do. But I maintain that the vast amount of our troubles arises from drains not having been laid properly in the first instance. If well laid to begin with, and flushed at intervals, I cannot see that a drain ought to require attention for many years.

In the use of these culvert drains there is another very great advantage, viz., that they can be laid at an early stage of the work, with the covers laid in loose and a board or two laid over to protect them from damage; they thus answer the useful purpose of draining off all slop and rain during the progress of the building. When the right time comes—just before completion—the loose covers can be taken off, the drain examined and any defects made good, and the whole sealed up.

I have had these drains made in the ordinary glazed earthen ware, but I have also had some made in Portland cement in which a surface as smooth as glass can be obtained. I have not used any of these cement drains yet, but I should think that when the joints are neatly made, the aspect must be a most fascinating one.

R. NORMAN SHAW, R. A.

29 Bloomsbury Square, W. C., June 25, 1888.



THE BALLISTIC PENDULUM.

WRITING on the ballistic pendulum of Robins, Professor Greenhill says this instrument "enables us to dilute the velocity of the bullet so as to make it easily measurable, and by firing at the pendulum from different distances, and calculating the loss of velocity through the air, we are able to obtain a fair estimate of the resistance. Robins found in this manner that the resistance of the air to a bullet ¾ in. diameter, weighing one-twelfth of a pound, is about 10 lb., or 120 times the weight of the bullet, at a velocity of about 1,600 ft. per second. By firing with a charge of powder half the weight of the ball at the ballistic pendulum at ranges of 25 ft., 75 ft., and 125 ft., he found that the mean velocities of impact were respectively 1670, 1550, and 1425 foot-seconds. Now denoting by R the average resistance in pounds over the first 50 ft., in which the velocity fell from 1670 to 1550, the principle of energy gives, in foot-pounds, 50 R = (1670

$-1550^2) \div (2 \times 32 \cdot 2 \times 12)$, or R = 10. Robins, on the principle of mechanical similitude, shows that a 24 lb. cannon ball fired with a charge of 16 lb. of powder should acquire a velocity of 1650 foot-seconds, and that the resistance of the air would then amount to 540 lb., or nearly twenty-three times the weight of the shot."

STEAMSHIPS OF THE CANADIAN PACIFIC RAILWAY COMPANY.

THE Naval Construction and Armaments Company have launched from their yard at Barrow a magnificent twin screw steel steamer, the first of three to be built by order of the Canadian Pacific Railway Company. This forms a necessary link between two important parts of our colonial empire, and will enable the Canadian Pacific Railway Company to carry passengers for China and Japan with great speed and comfort. The Canadian Pacific Railway, which was commenced in 1880, and, under contract with the government of the Dominion of Canada, was to be completed in October, 1890, was actually finished, and had trains running through from Halifax and Quebec to Vancouver, in November, 1885. The imperial government called for tenders for a mail service by first class steamships between Vancouver and Japan and China, specially constructed to carry troops and guns. The three vessels now building by the Naval Construction and Armaments Company, Limited, at Barrow-in-Furness, are contracted to do 18 knots on the measured mile, and 16½ knots on a 400 miles' sea trial. Their engines indicate about 10,000 horse power, and they are propelled by twin screws, the engine room being divided by a fore and aft bulkhead, and the propeller, or tail end shaft, being carried within the structure of the hull to the very extremity, thus doing away with the external support known as the "A" bracket principle. The hull is subdivided by twelve transverse water tight bulkheads. Of these, three forward and two aft are without doors of any kind, while the remaining seven have specially constructed water tight doors, and all sluice doors in the bunkers are provided with screens to prevent falling coal blocking the doors. The four boilers supplying the engines with steam are placed in two compartments divided by a cross bunker, and are fully protected by wing bulkheads and side bunkers. Arrangement is also made for the protection of the engines by coal in the event of the vessels being taken up as armed cruisers.

The dimensions of the vessels are:

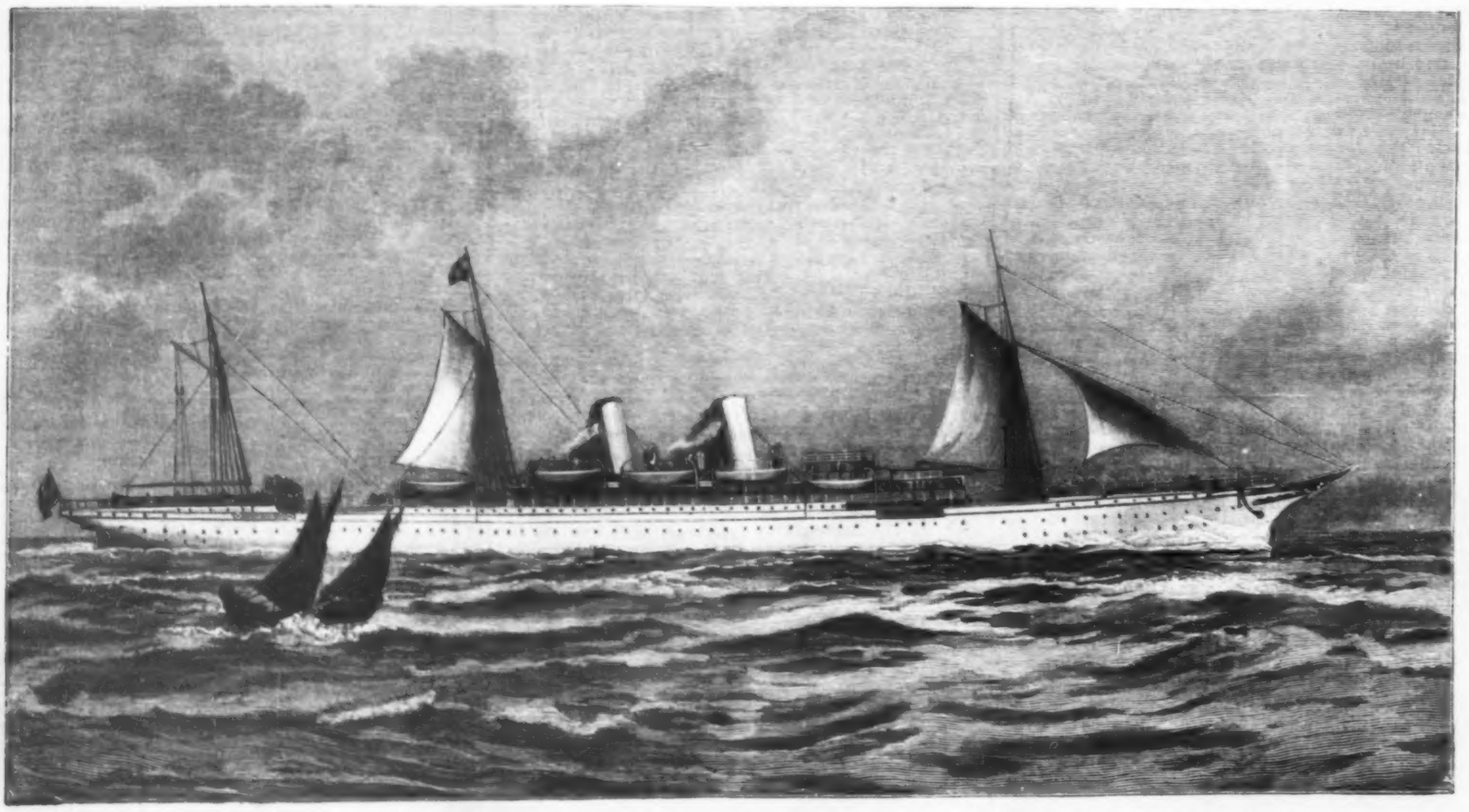
Length over all, 485 ft.; between perpendiculars, 440 ft.; breadth, moulded, 51 ft.; depth, moulded, 36 ft.; tonnage, 5,700 tons gross.

They are lightly rigged with pole masts and fore and aft canvas, and their form, both under and above water, is of such symmetry and fineness as to insure their easily attaining the high speed required. The steering engines, which are of the best and strongest make, are connected with a drum working on the rudder head, which is again controlled by a patent hydraulic brake.

The arrangements and fittings for passengers are of the most complete and luxurious kind. The vessels are lighted throughout by electricity, and are thoroughly ventilated by a series of electric fans, each three feet in diameter and delivering about 400,000 cubic feet of air per hour. The vessels will carry, in addition to passengers, about 4,000 tons of tea, and are specially designed with side ports and side hatches, arranged with a view to the speedy reception and delivery of cargo.

The armament of the ships will consist of the latest type of 4·7 in. guns, which will be stored at Vancouver and Hong-Kong, so that the ships can be fully armed and made ready for their cruiser duties in the space of a few hours.

It is the intention of the company to dispatch these vessels to their stations as soon as they are delivered by the builders, and an opportunity will be afforded to passengers to make a trip round the world, proceeding to China through the Suez Canal, calling at all the various ports of interest *en route* from China to Japan, and across the North Pacific Ocean to Vancouver, whence the trans-continental journey will be made by the trains of the Canadian Pacific Railway to Montreal and New York, at which ports the passengers will have a choice of the Atlantic lines to return to Europe.—*The Illustrated London News.*



THE CANADIAN PACIFIC RAILWAY COMPANY'S NEW STEAMSHIP EMPRESS OF INDIA.

COTTON FLANNELS.

THE preparing of cotton for cotton flannels, says a contemporary, must receive the greatest care to insure success. An even blending of the warp and weft is essential to procure an even nap on the cloth. There is quite a difference of opinion among weavers with regard to the condition of the cloth raising when sent to the raising room. The process of raising is not only a very peculiar one, but it is very severe on the cloth as well. Each yard of cloth must stand on its own merits during the process. There is the same strain brought to bear upon one square foot of cloth that there is upon another. It will, therefore, be seen by those interested how necessary it is for the cloth to be even. When the fact is taken into consideration that the fabric passes under the steel clothing of four, five, and often six machines, it is evident that it must be even and well woven to stand the test and come through all right as a first class flannel. We can see why it pays to buy good grades of cotton, as well as to carefully oversee the mixing, carding, spinning, and weaving, so that good cloth is sent to the raising room. Of course, there is a possibility of doing considerable damage in the processes by too much friction. Then, again, if the card clothing is not in proper condition, the cloth will suffer beyond redemption, and will either have to be thrown away or put into a lower grade of goods. Cloth well milled and carefully handled at the processes of napping will present a beautiful, soft nap. Several years ago, there was quite an animated discussion with regard to the merits of steel card clothing for raising machines. I was more than usually interested in the subject, because I had heard so many express adverse opinions as to the policy of ever attempting to use it. Since that time, I have been looking for the results that many objectors presented as good and sufficient reasons why steel wire should not be used. It was a question that was debated with great vigor, and there was much doubt as to whether it could be successfully used with safety, but I think I have been thoroughly convinced that hardened and tempered cast steel wire, as has now been introduced in these processes, will take the lead of all other wires, both for cards and nappers, and this brings me to the point that has not yet been spoken of. There is probably not a harder and more trying place for card clothing than on raising machines, for the strain that is brought to bear on the wire far exceeds that on all other machines. I presume woolen cards will approach nearest to them in this respect. The grade of cloth to be raised has a good deal to do with the durability of the wire. Cloth of the weight of two yards to the pound will put the wire under a much greater strain than cloth of the weight of four yards to the pound. The number and setting of the wire has to be taken into account when clothing is being ordered. There has always been one serious difficulty in using Bessemer wire, and that was the very narrow margin card makers had in setting wire. That is to say, No. 33 wire was as far as they dared to go on account of its being weak and not able to stand up to the strain. On the other hand, too coarse numbers would not work well, and so the limit either way was very close. The breaking out of napping wire has necessitated a large expense in replacing the clothing, but, as there was no alternative, manufacturers have kept on in the same direction for years. It seems, however, that we have now reached the last milestone in the use of common wire for raising cloth, from the fact that tempered steel wire is now being introduced into all the departments where cloth is being raised. There has been great reluctance on the part of very many of our manufacturers in adopting this new method, especially for cotton cloth. What was feared the most was the risk of fires. Another reason has been advanced by some of the shrewdest managers, and that is that steel wire, instead of drawing out the cotton fibers and leaving a soft nap, would cut the fibers by reason of the sharpness of the teeth. But these results have not been realized as was anticipated, for no fibers have occurred, and so far from the cloth having been injured by the steel wire, it has actually done its work better than by the old method, and hardened and tempered cast steel wire is now extensively used in preference to common wire. . . .

As previously stated, there was a very narrow margin on wire, when the common kind was put on. Nothing finer than No. 33 could be used to advantage, and that was why steel wire was eventually substituted for iron wire. It was found that No. 35 steel wire would stand up and do most excellent work, especially where a light grade of goods was being napped. Less friction was required to perform the work. At the same time the cloth was left in a much better condition, with a fine, even, flossy nap drawn out. The process of raising cotton goods is one that requires great care, for the least deviation in the friction or strain is liable to spoil the cloth. The first process simply starts the fibers from the thread. Passing to the other machines, the raising is continued until finished. It has been found that, by the use of steel wire, a better nap can be produced both on heavy and light grades of goods. In setting steel wire for raising machines, the bend should be less than on regular wire, for there is less give, when they are brought to bear on the cloth. Some prefer an open space in the setting, but the usual way is to set them in solid sheets, with wire considerably shorter than the regular card clothing. The clothing, in order to insure the best results, should be drawn quite loose compared with card clothing on cotton or woolen cards. This will be found an actual necessity from the fact that a severe strain is brought to bear on the cloth. This is especially noticeable on light flannels. The number of points to the square inch is a matter of opinion, although the best theory now advocated is to leave them a shade open. One leading firm uses No. 32 wire with 34,000 points. No. 33 wire, at another place, runs from 46,000 to 48,000, while with steel wire, No. 35, the setting is from 55,000 up to 60,000 points. Another point on which I wish to speak is grinding. I am of the opinion that steel wire must be handled very carefully when ground. In fact, we cannot go too far in this direction. A very slight grinding is all that is necessary—just enough to take off the roughness. Steel wire will have to receive more care in setting than Bessemer steel. This is evident from the fact that hardened and tempered cast steel wire is not so elastic, and stands up to its work, and takes hold of the fibers more readily. What we want is that the wire shall be in such a condition, as far as the points are concerned, that after taking hold of the cloth, they will let go without any tear on the fibers. Very much depends upon the condition of the cloth, but if it is evenly milled, and the clothing is in good trim, with machines running steadily, there is no reason why a fine grade of cotton flannel should not be produced.

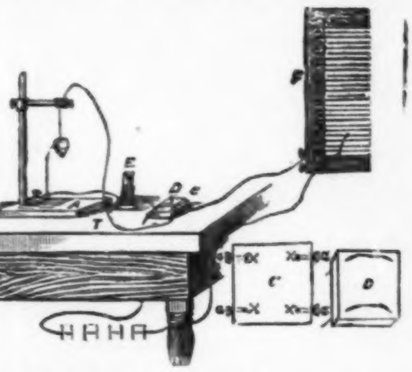
THE OXIDATION OF SULPHIDES BY MEANS OF THE ELECTRIC CURRENT.*

By EDGAR F. SMITH.

IN the *Proceedings* of the Chemical Section of the Franklin Institute, i., 52, and the *Berichte*, xxii., 1019, a preliminary report was published, describing a rapid method for the conversion of sulphur into sulphuric acid through the agency of the electric current. It was there demonstrated that the sulphur in the mineral chalcopyrite, for example, was completely oxidized to sulphuric acid in ten minutes, and that the oxides Fe_2O_3, CuO, etc., were eliminated from the analysis, so that the barium sulphate finally weighed was perfectly white in appearance, and not contaminated with the impurities usually accompanying it when precipitated from solutions containing much iron, etc.

To give a better idea of the mode of carrying out an oxidation of this description, the apparatus used for this purpose will be first outlined.

T represents a table upon which stands A, an ordinary filter stand, in the base of which is fixed a binding



screw holding in position a heavy copper wire bent as seen in the sketch, and intended to carry the nickel crucible in which the oxidation occurs. The arm of the filter stand has attached to it a binding screw holding a heavy platinum wire, as well as the copper wire generally in connection with the anode of the battery. E is a Kohlrausch ampere meter, registering amperes and half amperes; this is in connection with C, a block of wood screwed or nailed to the table. There are four depressions (x) in C containing a few drops of mercury, in contact with the binding screws (a). D is the movable top of C; the wires crossing it project on the under side and rest in the mercury cups (x). When D is so arranged that the wires on its upper face run in the direction of the dart, the crucible becomes the anode of the battery, whereas if they have a horizontal position, ⟶, the crucible is the cathode.

F is a resistance frame, consisting of about 500 ft. of common iron wire arranged upon a light wooden parallelogram. It should always be in the circuit.

The movable cap, D, is necessary and important. It enables the operator to change the poles quickly—to reverse the current at a moment's notice. In the oxidations to be described later on, this was frequently necessary, chiefly because when the crucible served as cathode in many of the decompositions there often occurred a considerable deposition of metal upon its sides, and in the act of separating this metal inclosed undecomposed material and withdrew it from the field of oxidation. In such cases, by making the crucible the anode, as above indicated, the mineral matter will be liberated, and upon coming in contact with a large oxidizing surface, all the sulphur contained in it will be converted into sulphuric acid. The crucible should always be covered during the oxidation.

Oxidation of the Sulphur in Sulphides.

In the oxidations given later, nickel crucibles 1¼ in. high and 1⅝ in. wide were used; but a more advantageous form, one which should always be employed when more than 0·15 grm. of material is used, would measure 2 in. in length and 1⅛ in. in width. In such a vessel place 25–30 grms. of pure potassium hydroxide (not sodium hydroxide), and warm the same until the excess of moisture is expelled. Bring the weighed sulphide into the crucible, connect the latter with the copper wire shown in the sketch, and lower the platinum wire so that it extends a short distance below the surface of the molten mass. The current is then made to pass by bringing a metallic cup, connected with one pole of the battery, in contact with one of the wires of the resistance frame, F. The sulphur will be completely oxidized in from ten to twenty minutes. Interrupt the current, allow the crucible and contents to cool, then place the same in water. In a few minutes all but the insoluble oxides will have dissolved. Filter, acidulate the warm filtrate with hydrochloric acid, and precipitate the sulphuric acid in the usual manner. If upon adding acid to the alkaline solution the latter becomes turbid, from separated sulphur, it is an indication that the oxidation was incomplete. Observe closely whether sulphur dioxide is liberated even when the liquid remains clear. Never omit the examination of the residue remaining on the filter, after the alkaline solution has been filtered. The caustic alkali must always be tested for sulphur before using it in this work. It is well to estimate the impurities in the alkali and deduct them, in each determination, from the barium sulphate found.

To ascertain to what extent this method could be applied in oxidizing sulphur, the following minerals, representing all the various classes of natural sulphides, were subjected to experiment:

Sphalerite (ZnS).

No difficulty was experienced in oxidizing the sulphur of this mineral. A current of one ampere (= 10·45 c. c. electrolytic gas per minute) was amply sufficient for the purpose. When the mineral was added to the melted caustic potash and the current applied, the mass assumed a muddy appearance, which it retained for ten minutes, when it became white and frothlike. It was discovered, by experiment, that this appearance indicated the complete oxidation of the sulphur.

1. 0·1195 grm. mineral, 20 grms. alkali, 1 ampere (time, 20 minutes), gave 32·97 per cent. S.

2. 0·1025 grm. mineral, 20 grms. alkali, 1 ampere (time, 20 minutes), gave 32·96 per cent. S.

3. 0·1180 grm. mineral, 20 grms. alkali, 1 ampere (time, 10 minutes), gave 32·80 per cent. S.

By oxidizing the sulphur in a fourth portion with nitric acid and potassium chlorate, 32·90 per cent. sulphur was obtained.

A specimen of Joplin (Mo.) blende gave 32·60 per cent. and 32·80 per cent. S by the nitric acid method, while by the electrolytic method 32·90 per cent. S was found.

An impure sphalerite, locality unknown, in which there was considerable gangue and other admixtures, gave 29·8 per cent. S when oxidized with nitric acid, and when acted upon in alkaline solution by a current giving one ampere of electrolytic gas per minute, the sulphur found was:

1. 29·33 per cent. S.
2. 29·45 " "
3. 29·68 " "
4. 29·67 " "
5. 29·90 " "
6. 29·58 " "

Cinnabar (HgS).

Very pure material was employed in this oxidation. Several trials were required, in order to learn the proper conditions for successful working. The tendency of this mineral, when finely divided, was to collect in lumps, which appeared to rise and fall in the alkaline solution; in order to bring every particle of material within the field of oxidation, the current was reversed every few minutes. By doing this the sulphur was completely oxidized in twenty minutes or even in less time. If the precaution just mentioned with reference to the reversal of the current be not heeded, more time will be required for complete oxidation, and even then it will be doubtful whether the sulphur is fully converted into sulphuric acid. Twenty-five grms. of caustic alkali were used in each experiment with this mineral.

0·1089 grm. cinnabar gave 13·82 per cent. S, while the required percentage is 13·79.

A current of two amperes per minute was used.

Galenite (PbS).

There is no difficulty in oxidizing this mineral. The same quantity of alkali and the same current strength were employed here as in the mineral immediately preceding:

1. 0·1098 grm. galenite gave 14·30 per cent. S.
2. 0·1092 " " " 14·60 "

Another portion in which the sulphur was oxidized by heating the mineral in a current of chlorine gave 12·30 per cent. S.

Argentite (Ag_2S).

No difficulty was encountered in oxidizing this mineral. The decomposition was made with conditions analogous to those already described. Silver did not pass into the alkaline solution, so that when the sulphuric acid was precipitated, barium chloride was employed as usual. The specimen analyzed being exceedingly pure, it was not thought necessary to determine the sulphur by any other method. None of it remained unoxidized:

0·1032 grm. argentite gave 13·04 per cent. S; required 12·90 per cent. S.

Chalcocite (Cu_2S).

Thus far this mineral has resisted all efforts to convert its sulphur into sulphuric acid. Repeated attempts have been made, but not more than half of the sulphur contained in the mineral was oxidized, notwithstanding the current was very much increased in each trial. Since some time may elapse before another opportunity offers itself to continue experimentation with this mineral, it need only be stated that a modification of the usual method will be tried upon it. The copper and sulphur are evidently in very intimate union.

Molybdenite (MoS_2).

The sulphur in this mineral is given up readily to the oxidizing influence of the current. One annoying feature is that the fine mineral particles are so very light that they are apt to be carried up and adhere to the cover crystal. In this oxidation the poles should be repeatedly reversed. The result given below is from a sample that contained much quartz, etc. The residue, however, gave not a trace of sulphur when tested for it.

0·1045 grm. mineral gave 0·2785 $BaSO_4$ = 36·60 per cent. S.

Stibnite (Sb_2S_3).

While a current of two amperes was employed in this oxidation, the sulphur can be completely changed to sulphuric acid with one ampere. Three trials proved this conclusively.

0·1095 grm. mineral gave 0·2230 $BaSO_4$ = 27·91 per cent. S; required sulphur, 28·5 per cent.

Orpiment (As_2S_3).

Pure material could not be obtained, so that the experiments were made with inferior mineral, and the greatest care was given the oxidation, so that sulphur was not afterward discovered in the insoluble residue.

0·1150 grm. sub. gave 0·2922 gr. $BaSO_4$ = 34·90 p. c. S.
0·1044 " " " 0·2721 " = 35·79 " "

The arsenic was also oxidized to arsenic acid. Several tests proved the conversion to be quantitative. Results obtained in this direction will be published later.

Jamesonite ($Sb_2S_5Pb_2$).

The sulphides of lead and antimony offer no difficulty in the oxidation of their sulphur. This sulpho salt is decomposed with equal facility. A current of two amperes per minute was employed. The crucible was the anode for ten minutes, and the cathode for an equal period.

1. 0·1078 grm. mineral gave 0·1426 gr. $BaSO_4$ = 18·16 per cent. S.

2. 0·1093 " " " 0·1447 " = 18·18 per cent. S.

Required S = 18·30 per cent.

Enargite (AsS_4Cu_3).

The oxidation was made in the same manner as in jamesonite:

0·1102 grm. mineral gave 0·2449 gr. $BaSO_4$ = 30·52 per cent. S.

A second sample, oxidized with nitric acid, gave 31·00 per cent. S.

Stephanite (Ag_5SbS_4).

This mineral was oxidized without difficulty. The conditions under which it was worked were similar to those of the preceding minerals:

1. 0·1044 grm. substance gave 16·69 per cent. S.
2. 0·1109 " " " 16·55 "

Theory requires 16·20 per cent. S.

Kobellite [$(BiSb)_2S_5Pb_2$].

The sulphur in this mineral was oxidized with ease:

1. 0·1136 grm. sub. gave 0·1562 gr. $BaSO_4$ = 18·38 p.c. S.
2. 0·1157 " " " 0·1594 " = 18·41 "

The sample here oxidized was of the same material as that analyzed by Dr. Keller (*Proc. Chem. Soc. Franklin Inst.*, 1, 127). On comparing the mean of his four sulphur determinations with the results obtained by the electrolytic method, it will be seen that the latter does not lack in completeness:

Current Oxidation.	Nitric Acid Oxidation.
Sulphur percentage.	18·37, 18·33, 18·46, 18·30
18·39–18·41	Mean, 18·39 per cent. S.

Tetrahedrite $(Sb,As)_2S_7(Cu_2,Hg_2,Fe,Zn)_4$.

Quite a number of sulphur determinations and complete analyses of tetrahedrite of the above composition were made in this laboratory during the college year just closed. In all these the chlorine method was employed for decomposition purposes. The percentage of sulphur found was 24·48 per cent. Samples of the same were then exposed to the action of a current of two amperes for twenty minutes, and the sulphuric acid determined in the usual manner with these results:

1. 0·1073 gr. mineral gave 23·81 per cent. S.
2. 0·1096 " " 24·38 "
3. 0·1086 " " 24·23 "
4. 0·1095 " " 24·37 "

Tetrahedrite seemed to require the full time (twenty minutes) for oxidation, for in several instances, where the current was interrupted after acting fifteen minutes, the alkaline solution became quite turbid upon acidulation.

Stannite (Sn_4SCu_2Fe).

The conditions here were the same as those already mentioned for the other sulpho salts:

1. 0·1087 grm. mineral gave 28·61 per cent. S.
2. 0·1091 " " " 28·02 "

Pyrrhotite ($Fe_{11}S_{12}$), *Marcasite* (FeS_2), *and Pyrite* (FeS_2).

The sulphur in the first of these three minerals is very readily changed to sulphuric acid. None of its iron passes into solution, so that the barium sulphate, after ignition, was perfectly white in color. The residue, not soluble in water, showed no unoxidized sulphur:

1. 0·1087 grm. mineral gave 0·3049 gr. $BaSO_4$ = 38·51 per cent. S.

2. 0·1067 " " " 0·3014 " = 38·79 per cent. S.

By oxidation with nitric acid the sulphur found was 38·78 per cent. S.

An exceedingly pure specimen of marcasite was exposed to the action of the current. Its sulphur was rapidly and completely oxidized:

0·1043 grm. substance gave 0·4056 gr. $BaSO_4$ = 53·40 per cent. S. Required S = 53·33 per cent.

While these sulphides of iron parted with their sulphur with great ease, pyrite held half of its sulphur content quite tenaciously, notwithstanding it was exposed to the influence of much more powerful currents than the other two minerals.

1. 0·1667 grm. pyrite and 20 grms. KOH were exposed for ten minutes to the action of a current giving one ampere per minute. The crucible served as anode for half the time. The sulphur that was oxidized equaled 24·53 per cent.—*Chem. News.*

* Read at the Chemical Section of the Franklin Institute, June 17, 1890.

NEW PROCESS OF OBTAINING OXYGEN.

By FRITZ SALOMON, of Essen-on-the-Ruhr, Germany.

WHEN a mixture of lead monoxide (PbO) and of an alkaline earth is at a red heat brought into contact with a current of atmospheric air, oxygen is absorbed and lead dioxide (PbO_2) respectively plumbate (R_2PbO_4) are formed. This chemical reaction is well known and has been clearly demonstrated by the researches of Dr. Kassner. If the lead compound be now brought into contact with carbonic acid gas, the previously absorbed atmospheric oxygen is driven off and a mixture of earthy alkaline carbonate and of lead monoxide is formed. The temperature at which the lead oxide mixture absorbs atmospheric oxygen and at which carbonic acid drives the oxygen off are not far apart.

My process consists in heating a mixture of lead monoxide and alkaline earth—for instance, lime—to a good heat in a retort, so as to absorb oxygen from the atmospheric air. In place of lead monoxide other compounds of lead may be used—such as carbonate—which are transformed into monoxide by heat. The proportions of the constituent parts of the mixture may be varied; but it is desirable that for one equivalent of lead monoxide from one to two equivalents of lime should be present. The mixture is heated to a red heat, or to about 800° to 1,000° Centigrade. A current

of atmospheric air is then passed over it, the oxygen of which is absorbed while the nitrogen escapes. When carbonate is used in place of monoxide, nitrogen and carbonic acid escape together. The absorption of the oxygen at the proper heat is soon completed, being effected through the admixture of lime as follows: $2CaO + PbO + O = Ca_2PbO_4$. After the saturation of the mixture with oxygen, when the temperature has fallen to a certain point, the current of air is turned off and carbonic acid gas is passed over the glowing compound, whereby the oxygen is expelled while the carbonic acid combines with the remaining calcium oxide. The reaction is as follows: $Ca_2PbO_4 + 2CO_2 = 2CaCO_3 + PbO + O$. The oxygen driven off by this reaction is collected or carried off for immediate use. The reaction is so rapid that at first only pure oxygen is given off so that it can be collected without difficulty. At the close of the operation some carbonic acid passes off, and this is easily removed by an absorbent, such as lime or sodium carbonate. The mixture of calcium carbonate and lead monoxide remaining in the retort after the expulsion of the oxygen is immediately treated with air while at a red heat, or to hasten the expulsion of the carbonic acid with a mixture of air and steam. The same reaction—namely, the absorption of oxygen by the mixture—is effected and the process may be repeated at pleasure. The regeneration of the mixture of the carbonate of an alkaline earth and of lead monoxide remaining in the retort after the expulsion of the oxygen has the advantage that it makes it possible to regain the greater part of the carbonic acid for future use.

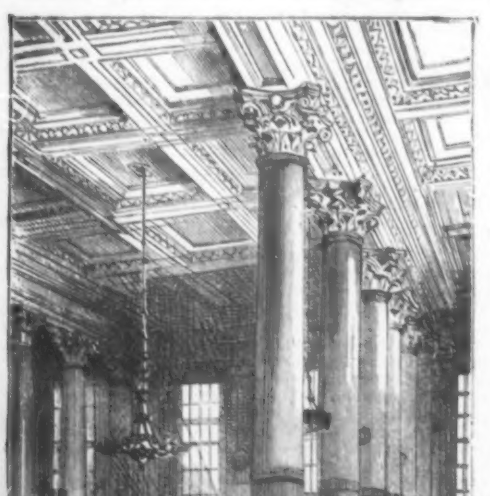
Other metallic oxides than lead monoxide are applicable for obtaining oxygen by the above described process, for instance, the lower oxides of manganese, which at a red heat form with oxygen the higher oxide of the metal combined with an alkaline earth, and which combinations are likewise decomposed by carbonic acid; but the expulsion of oxygen is not as readily effected as with the lead compounds. It is to be further remarked that both the oxygen of the pure dioxide—for example, PbO_2 (or MnO_2)—and of the corresponding metallic peroxide—for example, red lead (PbO_2PbO_4)—is readily driven off by carbonic acid.

KING'S COLLEGE, LONDON.

A MEETING, over which the Duke of Wellington presided, was held at the Freemasons' Tavern, on

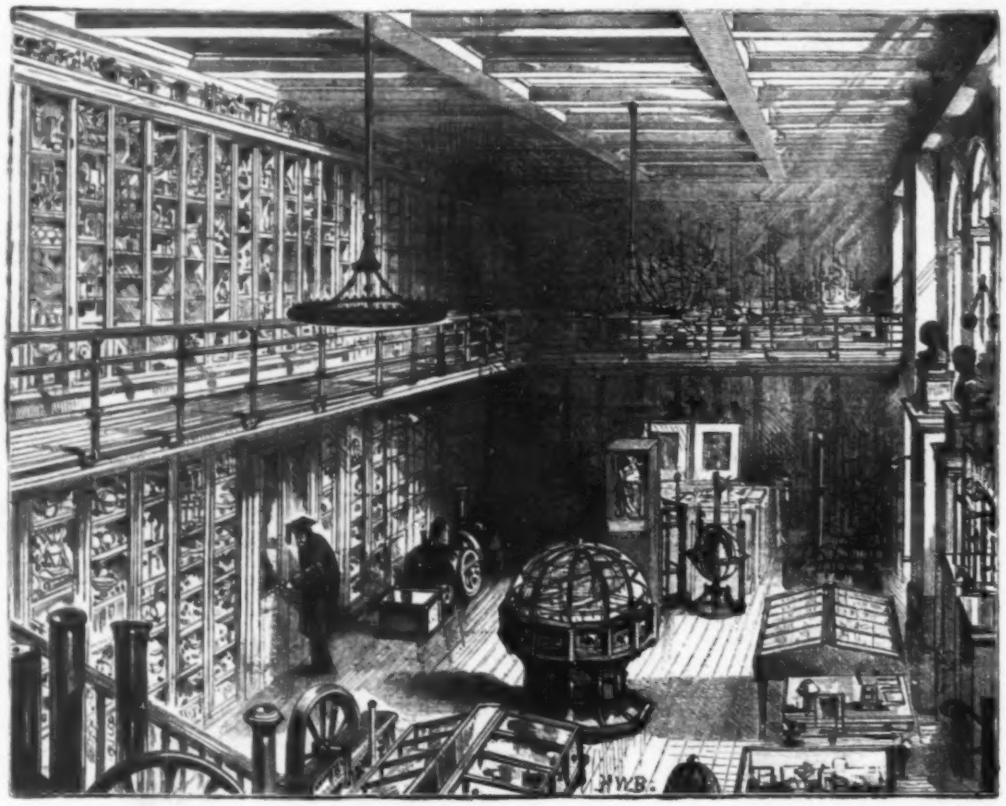
EXTERIOR OF KING'S COLLEGE.

Saturday, June 21, 1828, at which it was resolved that a college for general education should be founded in the metropolis, in which, while the various branches of literature and science were made the subjects of instruction, it should be an essential part of the system to imbue the minds of youths with a knowledge of the doctrines and duties of Christianty as inculcated by the United Churches of England and Ireland, and that the king having graciously pleased to signify his approbation of the establishment of this college, his Majesty should be most respectfully requested to take it under his royal patronage, and permit it to be entitled "King's College, London."



THE COLLEGE HALL.

In accordance with this resolution a royal charter was applied for, and granted in the year 1829, and subscriptions to a very large amount flowed in. In fact, no less than 150,000*l.* was expended upon the building and establishment of the college. It was opened October 8, 1831, by a service in the chapel, at which Bishop Blomfield preached a sermon upon "The combination of religious instruction with intellectual culture."



GEORGE III. MUSEUM.

As originally constituted King's College consisted simply of the department of general literature and science, called the senior department, and the junior department or school. Subsequently, however, three other departments were established. The first was the medical school. A little later on, in 1838, an engineering school, called the "Department of Applied Sciences," was added, and, in 1847, a theological department was established for the preparation of young men who intend to take holy orders. The hospital was first established in 1839, but in 1861 was rebuilt at the cost of 100,000*l.*

The building of King's College forms a wing to Somerset House. The principal's dwelling is, in fact, a portion of the water front of that building, and commands most beautiful views up and down the river. The main body, however, of the structure is at right angles to this, and forms the eastern side of a narrow quadrangle.

It was designed by Sir Sidney Smirke, and though a correct example of classical architecture, it is somewhat cold and uninteresting. In the center is the entrance, which admits one into a lofty entrance hall, with double staircases. Immediately opposite to the entrance, below a stone gallery, is the doorway leading into the college hall, a rather fine apartment with a flat ceiling supported upon a double row of Corinthian columns. Here all public meetings connected with the college are held, and some of the classes, which are very numerously attended, meet. Over the hall, and entered from the stone gallery before alluded to, is the chapel, which was reconstructed as it at present appears from the designs of the late Sir Gilbert Scott, R.A.

It is in the Florentine-Romanesque style. The columns are of iron, and the walls are inlaid with patterns and mosaics, executed in various colored woods. The altar is placed in an apse at the east end, and has a finely carved reredos of alabaster and mosaic. Every portion of the chapel is covered with mosaic or decorative painting, and the windows are all filled with stained glass, memorials of former professors and students of the college.

Near the chapel is "The Museum of George III.," so called because the nucleus of it is formed from the apparatus collected by George III. for the instruction of his children in Kew Palace. The collection was given to King's College at the accession of her Majesty, and has since been largely added to, especially by Wheatstone and Faraday, who both carried on their experiments and made many of the valuable discoveries with which their names are associated within the walls of the college.

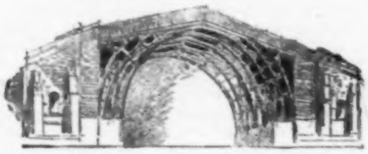
Among the objects which belonged to George III. are two very prettily mounted globes. The orrery, made for George II., is a very handsome object, more remarkable, in fact, for the beauty of its "mounting" than for any scientific value. The stand is composed of ebony inlaid with silver, and supported by horses' heads in ormolu. The most interesting objects contained in this museum, however, are the curious machines constructed by Newcomen, Wheatstone, and Faraday, which have formed important links in the history of scientific discovery.

Newcomen's model for his steam engine claims spe-

INTERIOR OF THE CHAPEL.

cial attention, and was the first in which "the beam" was used, constructed nearly seventy years before the time of Watt.

Faraday's "Siberian magnet" is a singular-looking object, and is said to have been the first "natural magnet" from which a spark was obtained. It is covered with curious paintings, and dated 1774.



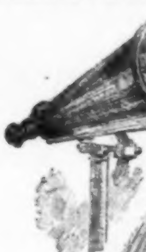
MODEL OF THE FIRST IRON BRIDGE.

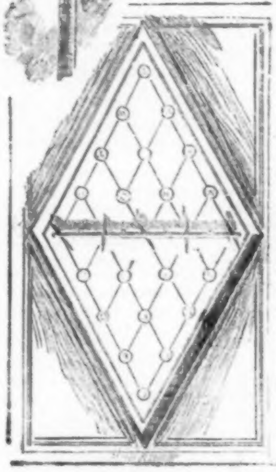
Two very strange musical instruments made by Wheatstone, who was for some years professor at King's College, will interest our readers on account of their great peculiarity. They are a "wind fiddle" and a "gas organ." The first is really a violin played by wind. Two hand bellows act upon the strings and set them vibrating. In the "gas organ" the pipes are of glass, and a jet burns under the mouth of each pipe. A valve is opened by pressing down one of the manuals of the keyboard, and this creates a rush of wind through the pipe, which thus gives forth its note.

Wheatstone was in his youth apprenticed to a musical instrument maker, and this may account for his turning his mind to these curious inventions.

The "sky clock, for telling the time of day by noting the polarization of the sky," is another ingenious ma-

WHEATSTONE'S POLAR CLOCK.





WHEATSTONE'S TELEGRAPH DIAL.

chine, but what are the most valuable objects, from a scientific point of view, are undoubtedly the electric machines and telegraphic apparatus with which Wheatstone made so many of his magnificent discoveries. It has been claimed that the electric telegraph itself was discovered by him at King's College. The practical working of that great invention was certainly shown to the late Prince Consort by Sir C. Wheatstone in 1843, when messages were dispatched from the college to a station on the opposite bank of the Thames, and a rocket exploded from the shot tower by a current sent from a battery at King's College.

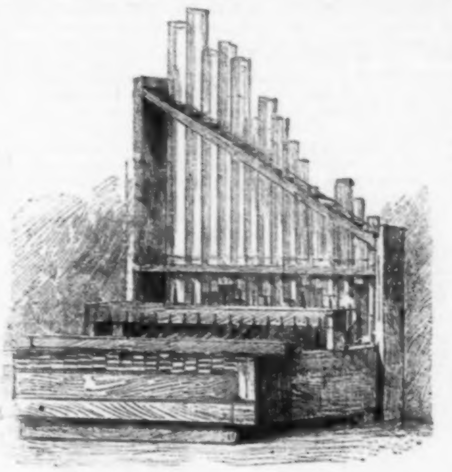
The telegraph dial which we illustrate is supposed to be one of those then used, and is probably the oldest in this country.

In a room adjoining the George III. museum is a

WHEATSTONE'S WIND FIDDLE.

model of a very elegant and curious wooden bridge constructed over the Rhine at Schaffhausen, by two local carpenters, in the eighteenth century. This very interesting structure was destroyed by Napoleon the Great for strategical purposes, and has never been reconstructed.

There is another excellently arranged museum at King's College, which is devoted to natural history, with an anatomical gallery attached. The room in which the various specimens are collected is spacious and handsome, and as it is entirely lighted from the roof, it is admirably adapted for purposes of study, and the careful inspection of its valuable contents. A light gallery runs round the room, with a kind of projecting desk, bracketed out over the balustrade,



WHEATSTONE'S GAS ORGAN.

upon which the more minute models and other objects are exhibited—an excellent arrangement, and one which might be more frequently adopted in our museums, public libraries, etc. There are, of course, several libraries attached to the college, two of which are the Marsden library and the general library. They are plain rooms, well stocked with books. The former contains a singularly valuable collection of Oriental literature.

NEWCOMEN'S STEAM ENGINE.

The class rooms, lecture rooms, and the school are well adapted to the purposes for which they are required.

It would be impossible here to enumerate the many eminent men who have been connected with King's College since its opening.

FARADAY'S SIBERIAN MAGNET.

In conclusion, we will quote a passage from the speech delivered by his Royal Highness the Prince of Wales, at the college jubilee prize distribution, July 2, 1881:

"Everything connected with this institution seems to be on a most satisfactory and excellent footing. In these days, when education is so much thought of, and when meetings are continually taking place in every part of the kingdom for the purpose of raising the standard of education, it is naturally difficult for institutions of old date to keep up with the times. But I do not think this college will have any reason to fear competition from others, as it already stands as at least the second or third of the great educational institutions of the kingdom."—*H. W. Brewer, in The Graphic.*

A SIMPLE WATCH DEMAGNETIZER.

THE accompanying illustration shows a novel method of removing magnetism from watches, which is very simple and is said to prove very effectual. This ingenious scheme is due to Mr. P. D. Richards, of West Medford, Mass. As is clearly shown in the illustration, the apparatus merely consists of a compound horseshoe

METHOD OF DEMAGNETIZING A WATCH.

magnet placed erect with its poles upward and a suitable support placed at some distance, perhaps two or three feet, above it. From this support is suspended by a twisted thread a cardboard tray in which is placed the watch to be demagnetized. When in position the supporting thread is allowed to untwist and the watch is gradually removed from the magnetic field. This simple device is easily constructed and seems well adapted to the purpose. Of course the same results could be obtained by the use of an electromagnet energized from a battery or other source of current as well as by employing permanent horseshoe magnets.—*Elec. World.*

THE HAZELTINE ARC LAMP CARBON SHIELD.

THIS is a simple and effective device due to Mr. W. B. Hazeltine, Jr., of the Hazeltine Electric Co., of St. Louis. This device, which is illustrated in the accompanying engravings, Figs. 1 and 2, consists simply of a sleeve of refractory material, forming a protective shield, or tip, which is freely suspended so as to hang in close proximity to the tip and the upper carbon close to the arc, the suspension device being so arranged that the sleeve is automatically maintained at its proper position near the arc. The effect of this simple arrangement, as has been shown by actual experience, is that the life of the carbon is practically

FIGS. 1 AND 2.—THE HAZELTINE ARC LAMP CARBON SHIELD.

doubled, so that an ordinary eight hour carbon is able to burn sixteen hours without retrimming. The exact action to which the saving in carbon and increase in life is due has not yet been fully analyzed, the fact remaining, however, as described. The shape of the carbon when protected by the shield is modified somewhat from that usually noted. The Hazeltine shield is considerably blunted, and the carbon shows a considerably larger crater than the unprotected one. The economical advantages gained by this device must be apparent. In the first place, not only may a large saving be effected in the carbon bills, but another important item, the cost of trimming lamps, may be reduced almost in the same ratio. A further attribute of the shield consists in the fact that it acts as an automatic cut-out whenever one or the other of the carbons is consumed, thereby preventing the destruction of the carbon holder, it being impossible, of course, for the holders to approach nearer to each other than the length of the shield. Aside from the economy in car-

bons and trimmer's services, it is pointed out that the convenience to customers of having their lamps trimmed every other day, instead of every day as at present, will no doubt have the effect of increasing the popularity of the arc lamp. Besides, the consumption of the carbon is so complete that very little carbon dust settles at the bottom of the lamp, so that cleaning may also be deferred to the same time as trimming.—*Electrical Engineer.*

[Continued from SUPPLEMENT, No. 781, page 12482.]

MILITARY SIGNALING.

THE flags and torches now used in army signaling are substantially the same as those used in the civil war, and, although another signal code has been adopted, the manner of using them remains substantially unchanged.

It is obvious that messages transmitted in the simple original form of the signal alphabet might be read

A SIGNAL STATION ON THE UPPER POTOMAC IN THE CIVIL WAR.

not only by the sending and receiving signalman, but by the enemy also. Early in the war cipher codes, based on the transposition of letters in many varying but methodical forms, were adopted. For instance the open sending of the letter *c* could be read by anybody familiar with the code, but *c* in a ciphered message might mean another letter known to the possessors of the cipher. The ciphers used were susceptible of daily or more or less frequent changes. Almost any cipher may be deciphered by experts, but the unraveling of the more difficult ciphers requires so much time that the final attainment may be valueless.

It is not intended here to recount the organization of the Signal Corps nor tell in detail of the operations of the Signal Service during the war. Signalmen served on reconnoitering and scouting duty to gain information of the country and of the enemy's movements; they served on outpost duty; they transmitted intelligence and orders within the lines of the army, and made communication possible between separated divisions of the forces. Long lines were operated by relays. From advantageous posts of observation they aided in directing the fire of batteries in action; they established communication between land forces and naval vessels, and made effective co-operation practicable. Their signals were waved from mountain tops and valleys, from trees and steeples, from camp and wharf, from lonely isolated stations, and on the field of battle. Every veteran soldier who recalls the war time will remember the wigwag, and how he wondered as he watched it what message its waving conveyed.

In the earlier part of the war electric field or flying telegraphs equipped mainly with dial instruments were to some extent operated by the signal corps. In 1863, by order of the War Department, all telegraph trains were turned over to another branch of the service, the military telegraph, posts in the military telegraph service were held by men who have become widely known as identified with the advance of telegraphy and in other pursuits. The wires were worked by practical telegraph operators. Their use was extended, and the click of the telegraph instrument was heard in trenches and on the field.

After the war the signal corps was disbanded, and the service of the military telegraph was discontinued. Instruction in military signaling was formally made a part of a course of study at the Military Academy and at the Naval Academy. Under an act passed in 1866, Col. Myer, who had remained in the service, was appointed chief signal officer of the army. Instruction in military signaling was given in the several military departments by line officers detached for that duty. A signal camp of instruction was maintained at Fort Myer, near Washington, until 1886. The weather service was established in 1870. The duties of the new service were placed in charge of the chief signal officer. The officers detailed as signal officers in the several military departments were called upon for weather duty, and instruction in military signaling was practically suspended. Non-commissioned officers, also, were detailed for weather service at various military posts, and at cities and other places throughout the country. Subsequent legislation enlarged the scope of the weather service, and while it provided for additional officers and men enlisted in the signal corps, their time was devoted principally to weather service.

Officers and men had received instruction in military signaling at Fort Myer. When the weather service was begun, instruction in the work of taking observations was added. The signal service became practically the weather service. Congress withheld appropriations, and in 1886 the signal school of instruction at Fort Myer ceased to exist. Recruits for the signal corps, which practically meant recruits for the weather service, were examined for general intelligence and special adaptability, at Washington or Chicago or St. Louis or other large city where a signal officer was stationed. If accepted, the recruit was assigned to a signal post for instruction. All signal officers and men were instructed in electric telegraphing as well as in visual signaling.

Brig. Gen. W. B. Hazen was appointed chief signal officer in 1880. The present chief signal officer, Brig. Gen. Adolphus W. Greely, famed for his explorations and meteorological researches, was appointed in 1887.

Morse invented for use with his telegraph an alphabet composed of dots and dashes, which were made by shorter or longer periods of transmission of the electric fluid. As is generally known, in its earlier use the characters of this alphabet were reproduced at the receiving end of the wire by marks on paper. In the original alphabet there were a number of so-called spaced letters. For example, S was a letter indicated by three dots separated by spaces of equal width: - - -; while C, a spaced letter made of three dots, had the regulation space between its first and second dots, but a wider space between the second and third dots: - - -; H was indicated by four dots equally spaced, - - - -; Y, a spaced letter of four dots, was made with the wider space between the two middle dots, - - - -.

In Europe Morse introduced with his telegraph a rearranged and improved alphabet of his own invention in which there were no spaced letters. The new alphabet was adopted in England and in Continental countries, and when Morse returned to the United States he endeavored to have it substituted for the old alphabet in this country, but he found it impossible. The operators had learned the original system and were familiar with its use, and they wouldn't change. The wide extension of telegraph lines called for a rapidly increasing number of operators who learned the original system, its use became established, and, with very few minor changes, it is the system now used in North America.

At an early period in the use of the telegraph it was discovered that the various sounds made by the clicking of the telegraph instrument conveyed to the practiced ear as distinct an indication of the letters made as the marks made on paper did to the eye, and, as is commonly known, reading by sound is now the almost universal practice. Notwithstanding the seeming greater simplicity of the English or Continental Morse code, it is said that the American Morse code is quicker in use.

While European countries adopted the American plan for military signaling, they did not adopt the Myer code of signals, but used instead, as they still do, a code based on the commercial telegraph code of their countries.

In the United States army the general service code was continued in use until 1886. In that year the Secretaries of War and of the Navy, having approved a joint report of a board of officers of the army and navy recommending the adoption of the English Morse code, for purposes of visual signaling in and between the army and navy, by direction of the Secretary of War an order was issued from the headquarters of the army discontinuing the use of the general service code of signals throughout the army and substituting the English Morse code. The same order provided for greater activity in signaling instruction and practice at the various posts and throughout the service.

Among the reasons for adopting the English Morse code were its international interchangeability for naval and other uses, and the exact adaptability of it to the motions already used in the general service code. Following is the English Morse code:

ALPHABET.

A - —	J - — — —	S - - -
B — - - -	K — - —	T —
C — - — -	L - — - -	U - - —
D — - -	M — —	V - - - —
E -	N — -	W - — —
F - - — -	O — — —	X — - - —
G — — -	P - — — -	Y — - — —
H - - - -	Q — — - —	Z — — - -
I - -	R - — -	

NUMERALS.

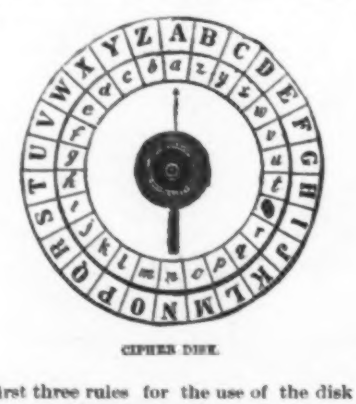
1 - — — — —	5 - - - - -	9 — — — — -
2 - - — — —	6 — - - - -	0 — — — — —
3 - - - — —	7 — — - - -	
4 - - - - —	8 — — — - -	

PUNCTUATION.

Period - - - - - -

In using the English Morse code for transmitting messages by flag or torch, the dot was represented by a motion to the right of the sender and a dash by a motion to the left; at the end of each word a "front" motion was made. These three motions were exactly the same as those prescribed for the motions 1, 2, and 3 in the general service code.

When the English Morse code was adopted there was also adopted a method of enciphering signal messages by the use of a cipher disk which is here shown:



CIPHER DISK.

The first three rules for the use of the disk are as follows:

1. If there be no previous agreement the letter "*a*" of the inner circle will be set opposite the letter "A" of the outer circle.

2. The message being written down in plain English by using the letters in the outer circle, the corresponding letters on the inner circle will be transmitted.

3. The message will be deciphered by writing down from the outer circle the letters found opposite the letters in the enciphered transmitted message taken on the inner circle.

These three first rules serve to illustrate the simplest form of the use of the disk. Suppose a message to be sent begins with the word "move." The letters sent would be, o, m, f, w, from the inner circle. The signalman receiving those letters would find opposite to them on his cipher disk, M, O, V, E, the word "move."

By preconcerted agreement any letter may be chosen on the inner circle as the key letter to be set opposite the A on the outer circle. Suppose the letter h were agreed upon as the key letter to be set opposite A. Then the word "move" would be transmitted from the inner circle, v, t, m, d.

Countersign words may be used, in which case the key letter is, at such times as may have been agreed upon, changed as often as there are different letters in the countersign words. Thus, suppose "wick" to be the countersign word agreed upon, the use of it to begin on a Monday and each letter to be used one day. On Monday the key letter on the inner circle to be set opposite A would be W. On Tuesday the key letter would be I, and so on. This is the simplest form of the use of the countersign word. The complications possible by the use of the cipher disk are numerous. The disk method of enciphering signal messages is the method now used.

When Gen. Greely became chief signal officer he favored the use of the American Morse code for all signaling purposes. In 1889 a radical change was made in the signal code of the army in accordance with the following order from the headquarters of the army:

The Secretary of War having approved a report of the chief signal officer, which proposes simplification of signal instructions, and renders possible in time of war the instant employment and utilization of skilled telegraphers for military purposes, it is hereby ordered that the American Morse code be used by the army for all purposes of signaling, whether visual or acoustic.

The use of the English Morse or Continental code, imposed by General Orders No. 12, series of 1886, from this office, will be discontinued throughout the army upon receipt of this order.

The following code card was issued. It is the code now used:

UNITED STATES SIGNAL AND TELEGRAPH CODE.

Authorized by General Orders No. 59, Adjutant-General's Office, June 28, 1889.

ALPHABET.

A - —	J — - — -	S - - -
B — - - -	K — - —	T —
C - - -	L ——	U - - —
D — - -	M — —	V - - - —
E -	N — -	W - — —
F - — -	O - -	X - — - -
G — — -	P - - - - -	Y - - - -
H - - - -	Q - - — -	Z - - - -
I - -	R - - -	& - - - -

NUMERALS.

1 - — — -	5 — — —	9 — - - —
2 - - — - -	6 - - - - - -	0 ——
3 - - - — -	7 — — - -	
4 - - - - —	8 — - - - -	

PUNCTUATION MARKS.

Comma - — - —	Interrogation — - - — -
Parenthesis Pn	Semicolon Si
Quotation Qn	Brackets Bx
Colon Ko	Paragraph — — — —
Dollar mark Sx	Period - - — — - -
Exclamation — — — -	Dash Dx
Hyphen Hx	Underline Ux

NOTE.—A fraction is made by inserting a dot between the numerator and denominator. Example: ⅜ — - - - - - - - - - -

SIGNALS AND ABBREVIATIONS.

1. Wait a moment.	Ahr. Another.
4. Start me.	Ans. Answer.
5. Have you anything for me?	Ck. Check.
7. Are you ready?	Col. Collect.
8. Busy on other wires (or stations).	D H. Deadhead.
	G A. Go ahead.
9. Train order (or important military message)—give way.	G E. Good evening.
	G M. Good morning.
	G N. Good night.
13. Do you understand?	G R. Government rate
18. What is the matter?	N M. No more.
27. Adjust your magnet (or flash).	O B. Official business.
	O K. All right.
30. Circuit closed (or close stations).	Opr. Operator.
	Pd. Paid.
44. Answer quick.	Qk. Quick.
73. Accept compliments.	Sig. Signature.
92. Deliver (ed).	
134. Who is at the key (flag or torch)?	

TO SIGNAL WITH FLAG OR TORCH.

The flagman faces exactly toward the communicating station; staff is vertical in front of center of body, but at height of waist. The *dot* (-) is represented by a motion to the right, and the *dash* (—) by a motion to the left of the sender. The *space*, whether separating elements of *spaced characters* (C, O, R, Y, Z, and "&") or separating words, will be represented by a "front" motion.

Thus the motions:

Right, right, front, right, represent C.
Right, front, right, represent O.
Right, front, right, right, represent R.
Right, right, front, right, right, represent Y.
Right, right, right, front, right, represent Z.
Right, front, right, right, right, represent &.

Each motion will embrace an arc of 90°, starting from and returning to the vertical.

The *long dash* (letter "L" and numeral "naught") is distinguished from the "*t*" dash by a slight pause at the lowest point of dip, and with this exception there

will be no pause whatever between the motions required for any single letter.

A slight pause will be made between letters.

At the end of each word, abbreviation or conventional signal the space signal or "front" motion is made, *preceded and followed by a pause* equivalent to that made between letters.

CONVENTIONAL SIGNALS FOR FLAG OR TORCH.

NOTE.—Each station should have its characteristic signal or call letter, as Washington, "W," and each operator his personal signal, as Jones, "Jo."

To call a station.—Signal the "call letter" of the station required, or, if the call letter be not known, signal "A" without pause until acknowledged. The calling station will then proceed with the message.

To acknowledge a call.—Signal "I" three times, followed by "front" and the call letter of the acknowledging station.

To break or stop the signals from the sending station.—Signal "A" without pause until acknowledged.

To start the sending station after breaking.—Signal "G A" followed by "front" and the last word correctly received; the sender will immediately resume his message, beginning with the word indicated by the receiver. If nothing has been received, signal "R R." The sender will then repeat all.

Error in sending.—Signal seven dots (- - - - - - -) rapidly followed by "front," and resume the message, beginning with the last word correctly sent.

End of address.—Signal the period (- - - - - -) followed by "front."

Signature follows.—Signal "Sig" followed by "front."

To acknowledge receipt of a message.—Signal "O K" followed by "front" and personal signal or initial of receiver.

CONVENTIONAL SIGNALS FOR HELIOGRAPH OR FLASH LANTERN.

To call a station.—Turn a steady flash on the station and keep it there until answered by a steady flash. Both stations will then adjust, each on the other's flash. When adjustments are satisfactory, the station called will acknowledge and cut off its flash, and the calling station will proceed with the message.

To acknowledge a call.—Signal "I" three times, followed by the call letter of the acknowledging station.

To break or stop the signals from the sending station.—Signal "A" without pause until answered by a steady flash.

To start the sending station after breaking.—Signal "G A," followed by the last word correctly received; the sender will immediately resume his message, beginning with the word indicated by the receiver. If nothing has been received, signal "R R." The sender will then repeat all.

Error in sending.—Signal seven dots (- - - - - - -) rapidly, and resume the message, beginning with the last word correctly sent.

Adjustment.—If the receiver sees that the sender's mirror needs adjusting, he will turn on a steady flash until answered by a steady flash. When adjustment is satisfactory, the receiver will acknowledge, and the sender will resume his message.

End of address.—Signal the period (- - - - - -).

Signature follows.—Signal "Sig."

To acknowledge receipt of a message.—Signal "O K," followed by personal signal or initial of receiver.

CONVENTIONAL SIGNALS FOR TELEGRAPH.

To call a station.—Signal the "call letter" of the station required until acknowledged, signing at intervals the "call letter" of the station calling.

To acknowledge a call.—Signal "I" three times, followed by "call letter" of acknowledging station.

To break or stop the signals from the sending station.—Open the key.

To start the sending station after breaking.—Signal "G A," followed by the last word correctly received; the sender will immediately resume his message, beginning with the word indicated by the receiver. If nothing has been received, signal "R R." The sender will then repeat all.

Error in sending.—Signal seven dots (- - - - - - -) rapidly and resume the message, beginning with the last word correctly sent.

End of address.—Signal the period (- - - - - -).

Signature follows.—Signal "Sig."

To acknowledge receipt of message.—Signal "O K." followed by personal signal or initial of receiver.

MESSAGES BY FLAGS, HELIOGRAPH, TELEGRAPH, ETC.

The following will be the order of transmitting the several parts of a message: First, number of message and "call letter" of sending station; second, operator's personal signal; third, the check; fourth, place and date; fifth, address in full; sixth, period (address complete); seventh, body of message; eighth, Sig. (signature follows); ninth, signature.

EXAMPLE.

The message—

"Washington, D. C., January 1, 1888.

"John Smith,

"80 State Street, Boston, Mass.

"Sent goods by express.

"Thomas Adams."

Would be sent—

No 2 W Jo 4 pd Washington D C 1 To John Smith 80 State Street Boston Mass. Sent goods by express Sig Thomas Adams.

Abbreviations should not be used in the body of a message, and numbers occurring therein must be spelled out in full.

A. W. GREELY, Chief Signal Officer.

Washington, D. C., July 1, 1889.

The American Morse Code has been adopted for signaling purposes in the navy. Naval officers also familiarize themselves with the English Morse Code.

Although the modern system of military signaling was originated and first used in active operations in this country, other nations are now in advance of us in the organization and equipment of signal corps, for they have continuously devoted much time and money to the development of strictly military signaling.

The flag and torch and other devices remain essential and important parts of signal equipment; under some conditions they afford the only attainable means of communication; and yet visual signals are now comparatively of secondary importance. For the various purposes of communication all modern nations now rely chiefly upon the electric telegraph and the telephone. There has been since the introduction of the telephone no large opportunity to test it in active operations in the field in time of war, but it is regarded probable that the telephone will become the principal means of army communication in all active movements. In all European countries especial attention is given to the use of the electric telegraph and telephone for military purposes. In the Franco-German war the electric field telegraph was brought into very general and efficient use in all military operations, and it has been operated in Egypt and on other fields of action.

In the civil war in this country a limited use of balloons was made by the Union and Confederate armies. In other countries armies are now generally provided with captive balloon equipments for observation and signaling purposes, the balloons and appliances for field uses being transported in wagons with the army. In this country there was electric telegraph or other signal communication between the balloon and the earth. The telephone is now an added means of communication. Plans have been made in this country for a balloon plant for the use of the army, but while the balloon may have advantages for purposes of observation and as an aid to reconnoissance, its unwieldiness and its necessary exposure to hostile shots seem to make a widely profitable use of it in the field improbable. In France experiments that are said to have been successful have been made with a dirigible balloon, but the more general impression is that practical success in the operation of flying machines under varying conditions remains to be accomplished.

In the siege of Paris in the Franco-German war balloons were used to convey dispatches and letters from the city, and carrier pigeons taken out in the balloons returned to the city carrying dispatches and letters. During the siege hundreds of thousands of dispatches and letters reached Paris by the carrier pigeon service. At first these dispatches were written by hand in minute characters, which were read by the eye or with the aid of a microscope. Various improvements were made in the method of preparing letters for transmission, and at last they were set in type, arranged in columns, and then photographed on very thin films of collodion. By reducing the photographic reproduction to microscopic size each film was made to contain about 2,500 dispatches. One bird could easily carry twelve films, containing about 30,000 dispatches. These transparent films were placed between two pieces of glass in a kind of magic lantern, and the messages were shown in large, legible characters on the wall. As many clerks as there were columns in the film all worked at once, each clerk copying a column, and thus the work of transcribing and sending out the messages was done rapidly.

In France experiments have recently been made with swallows as carriers, and it is thought possible that carrier swallows may be shown to be safer and swifter than pigeons.

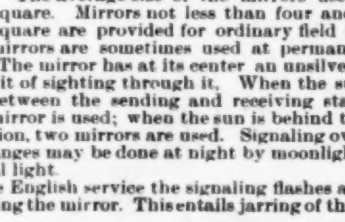
Almost every Continental nation now has a military pigeon system, and in some of them great attention is given to this means of communication. A station for experiment with homing pigeons for military purposes and for communication with naval vessels has been established at Key West in this country, and the somewhat limited experiments thus far made have been attended by a fair measure of success.

Signaling by reflected light has been in some form practiced in many lands, and from an early period in the world's history. About forty years ago English

HELIOGRAPH WITH TWO MIRRORS—SUN IN REAR.

army officers invented a heliograph for signaling by reflecting the sun's rays from a mirror. Conspicuous use of the heliograph has been made by the English in India and in Egypt, and by the French in Algiers. It is now used in many countries for army signaling and for other purposes. The heliograph has been greatly improved by American army officers. A notable improvement is the use of a screen for shutting off and revealing the flash instead of flashing the mirror. Briefly described, the heliograph is an adjustable mirror mounted on a tripod where portability is desired, or it may be attached to a fixed support at a permanent station. The average size of the mirrors used is six inches square. Mirrors not less than four and a half inches square are provided for ordinary field use, and larger mirrors are sometimes used at permanent stations. The mirror has at its center an unsilvered spot to permit of sighting through it. When the sun is in front, between the sending and receiving stations, a single mirror is used; when the sun is behind the sending station, two mirrors are used. Signaling over moderate ranges may be done at night by moonlight or by artificial light.

In the English service the signaling flashes are made by moving the mirror. This entails jarring of the instru-



HELIOGRAPH WITH ONE MIRROR AND SIGHTING ROD—SCREEN MOUNTED ON TRIPOD.

ment and the possibility of getting the mirror out of line. In this country, and in some others, the flashes are produced by moving the screen, which, when at rest, stands in front of the mirror and obscures the light reflected from it. The apparent motion of the sun makes occasional adjustment of the mirror necessary. Signaling is done by turning down the screen and revealing the flash. With the flag and torch the dots and dashes of the telegraph code are indicated by direction of motion; with the heliograph the dots and dashes are indicated by duration of the time of exposure of the light. A momentary display of the flash represents the dot and constitutes the unit of time.

The dash is represented by a display of the flash for a period of three units of time. The pause between letters is indicated by a period of obscurity for three units of time; the pause between words, by a period of obscurity for six units of time. Heliograph messages may be enciphered in precisely the same manner as by any other method of signaling.

The range of the heliograph with all conditions favorable is limited only by the convexity of the earth. Excellent results have been attained in the use of the heliograph in this country. Messages have been signaled successfully over a distance of 125 miles, and distances of 80 to 100 miles have not infrequently been covered.

Fifty-five miles is perhaps an average in ordinary operation.

The heliograph was used effectively in Arizona in the campaign against the Apache Indians in 1886. In that vast unsettled and diversified region it was not always easy to locate the Indians and keep track of them.

Heliograph stations were established all over the Territory, making a network of lines of communication. From these stations independent reports were made as occasion warranted. Scouting parties were accompanied by signalmen. Whenever the trail was discovered or other information of value was obtained it was from the nearest mountain or other available point signaled to the nearest heliograph station and thence to Gen. Miles. Distances of thirty, forty, and fifty miles between stations were readily covered, and greater distances by relays, and the heliograph was of great practical value in the successful conduct of the campaign.

The signal service is now experimenting with flash-light lanterns. A distance of thirty miles has been covered with the lantern now in use, and it is hoped that with further improvements the range of the lantern may be made to approximate that of the heliograph. The shade is operated by means of a key, which is fitted in the back of the lantern.

The uses to which electricity may be put in the active operations of armies in the field are not all determined. It is thought that use may be made of the microphone to detect the movement of troops. The arc light will doubtless be used for signaling purposes over long distances from permanent or semi-permanent stations and for purposes of illumination.

Among the various tests and experiments made by the Signal Bureau the telephone has received careful attention. The result is a perfected field telephone equipment known as the Eccard Kit, after Sergeant Eccard of the signal service, who contributed largely to its development, and who was at the time of his death, which occurred recently, the chief mechanic in the workshop attached to the bureau. The perfected field telephone has a transmitter and receiver in one piece, so that when the speaker's lips are at the transmitter the receiver is at his ear. This apparatus, which includes also a dry battery and a telegraph key attached, occupies but little space, and with half a mile of double insulated wire it can readily be carried anywhere in a knapsack. It serves equally well for use as a telegraph or a telephone. It might be made a part of the equipment of every company.

The uses to which the telephone may be put in battle and in other active operations are believed to be practically unlimited. In some form of operation the telephone will serve as a means of communication between army or corps commanders and division commanders, between division and brigade commanders, and if necessary between brigade commanders and commanders of regiments, and the commander of a regiment can communicate with his company commanders. Night or day the telephone may be used by men on outpost or picket duty for instant communication with the larger bodies of troops and with headquarters. The scout and the reconnoitering party may under many circumstances use the telephone, and without the delay and the danger of discovery incident to the necessity of seeking an elevated or other visible station from which to make visual signals. The wires can be laid by simply throwing them on the ground. When not in use they can be reeled up.

Of course the knapsack telephone illustrates only one form of its use. Telephone lines may be run from field trains as telegraph lines are now, or other and more ingenious methods of operation may be discovered.

Gen. Greely thinks that the telephone will become the controlling and general means of communication in active operations in the field. The flag and torch and other devices will remain in use for signaling over the enemy's head and for use under various other conditions in which they may furnish the only available means of communication, but he considers the telephone and telegraph as bearing the same relation to other means of signaling that the railroad does to other means of transportation.

In 1889 the Secretary of War issued orders which in effect provided that instruction in signal duties should receive at the various military posts still more attention than had yet been given to it, and that each company should at all times have a sufficient number of instructed offiers and men to maintain by signals distant communication in the field. Acting signal officers were detailed in the several military departments and great interest in signaling has been developed throughout the army. There is not at present an adequate supply of signal equipments.

Of the field telegraph equipment remaining at the end of the civil war, and which was subsequently turned over to the signal service, a part has been sent to the military post at San Francisco, and another part to the post at Leavenworth, Kansas. At Leavenworth a detailed signal officer gives instruction in all branches of signaling. Still another part of the equipment is to be sent to the cavalry and light artillery camp of instruction at Fort Riley, Kansas. A lieutenant of the signal corps has been ordered there

as instructor in military signaling and telegraphing. The telegraph train will be furnished with the most modern appliances. This is the beginning of a new departure in practical instruction in the field in all branches of military signaling. Wherever facilities are available enlisted men of the line are now instructed in electric telegraphing as well as in visual signaling.

In several States military signaling has been taken up by the National Guard. In California, Colorado, Connecticut, Iowa, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Vermont, and Wisconsin, particular attention has been paid to the subject of signaling, and from some of these States creditable progress is reported. Notable proficiency has been attained in this respect in the signal corps of the National Guard of the State of New York.

In 1878 Congress provided for the appointment of two second lieutenants of the signal corps, to be selected from among the sergeants of the signal service then on duty as observers. Thereafter provision was made for the appointment of two second lieutenants each year until 1886, but no provision was made for the promotion of these officers. Of the sixteen appointed, fourteen now remain in the service. All were assigned to duty in the weather service, and nearly all of them have remained continuously on duty in that service.

At its last session Congress passed an act which was approved Oct. 1, 1890, to increase the efficiency of the signal corps and to transfer the weather service to the department of agriculture. The act provides that the civilian duties now performed by the signal corps of the army shall devolve upon a bureau to be known as the weather bureau, which on and after July 1, 1891, shall be established in and attached to the department of agriculture, and that the signal corps of the army shall remain a part of the military establishment under the direction of the secretary of war. The chief signal officer is to have charge, under direction of the secretary of war, of all military signal duties and of all devices connected therewith, including telegraph and telephone apparatus and the necessary meteorological instruments for military uses.

The act provides that the weather bureau shall consist of one chief of weather bureau, who, under the direction of the secretary of agriculture, is to have charge of all duties pertaining to the weather service, and such civilian employes as Congress may annually provide for and as may be necessary to perform the duties of the bureau. And it is further provided that the chief signal officer of the army may, in the discretion of the President, be detailed to take charge of the weather bureau, and that other officers of the army, not exceeding four, expert in the duties of the weather service, may in like manner be assigned to duty with the weather bureau.

It is thought that the services of these army officers expert in weather service may be required, pending the training of civilian experts in forecasting.

The act provides that in addition to the chief signal officer, the commissioned force of the signal corps shall hereafter consist of one major, four captains (mounted), and four first lieutenants (mounted), who shall receive the pay and allowances of like grades in the army.

These officers are to be appointed from the army, including lieutenants of the signal corps, preference being given to officers who have performed long and efficient service in the signal service. Second lieutenants of the signal corps not promoted under this act are to be appointed second lieutenants in the line of the army. Provision is made for appointments and promotions in the commissioned force of the signal corps after this reorganization and the act provides also that the enlisted force of the signal corps of the army shall hereafter consist of fifty sergeants.—*N. Y. Sun.*

THE COMMON WALNUT.

(JUGLANS REGIA.)

THAT the class of soil required for the development of the common walnut to a great extent lessens the cultivation of the tree in this country cannot be denied. Such a soil as will produce a good crop of wheat is perhaps the best suited for the tree, although in deep alluvial deposit it does well, attains to a large size, and produces a fair quantity of timber, not, however, of so good quality generally as that grown on the strong stiff loam. Where but a small quantity of soil overlies the chalk escarpment, there, too, the walnut does fairly well, a fact that I could not help noticing the other day on seeing about a dozen big specimens growing around the banks of a disused chalk pit in mid-Kent. The position was not a sheltered one, and yet underwhat we might term disadvantageous circumstances as regards both soil and site, the trees have attained to a good old age without the least trace of disease, and still seem full of life and vigor. At several other places of late I have noted that the walnut is no second rate tree for planting on chalky soils, at least where a quantity of loam of a heavy, strong nature is incorporated with the chalk-drift, but it will not grow in anything like a satisfactory way where only an inch or two of soil overlies the hard unbroken rock. Like most of the other chalk-loving trees, the walnut must have the rock well broken up at the time of planting, and this is amply repaid by the more rapid rate of growth of the trees.

The timber of the walnut is of great value for the better classes of furniture and for gun stocks, while the fruit will in most instances pay the rent of the ground on which the trees are growing. Some of the timber grown in this country, and of which I have had ample opportunities of judging, seems not one whit behind such as is sent from the Continent.

As an ornamental tree the walnut is quite distinct from almost any other of our generally cultivated forest trees, the ample glossy foliage, which becomes fresh and cleansed by every shower, contrasting markedly with that of the oak, willow, and ash. A great value attached to the tree, too, is that the leaves drop all at once or nearly so, none of the littering and mess occasioned by the linden and other trees taking place with the walnut. Then grass grows freely in park or paddock beneath the shade of the walnut—a good point and one much in favor of standard, lawn, or field trees. There is a pretty and very distinct form of the tree in which the leaves are deeply cut or laciniated, and which when placed in clumps of three or five associate well with the typical species. It is known under the name of laciniata, produces larger fruit, and retains its leaves much longer than does the type. The black walnut (*J. nigra*) grows well with us on a stiff clayey loam, and forms a distinct and desirable species. It is perhaps not generally hardy, but in favored situations it attains to a good size and is highly ornamental. Where a piece of strong loamy land can be spared, I would strongly advise that the walnut be planted.—*A. D. Webster, The Garden.*

ELECTRIC TRANSMISSION OF POWER AT CALAIS.

FOR the past three months the Northern Railway Company of France has had in operation at Calais an electric light installation which possesses some peculiar features. At Calais three stations require lighting, namely, the town station, the harbor station and the goods depot. The generating plant is situated close to the town station, but is several kilometers distant from the harbor station and goods depot. The plant consists of two 150 horse power Chaligny engines, four 13 kilowatt (65 volts × 200 amperes) compound-wound dynamos and four series-wound dynamos having a maximum output of 27 amperes and 1,200 volts (32·4 kilowatts). At the harbor station there are two series-wound motors, which drive two low tension dynamos through shafting. At the goods depot there is one series-wound motor, which drives two low tension dynamos. The electric transmission of power is carried out on Brown of Oerlikon's principle; that is to say, a series-wound motor is driven by a series-wound generator at an almost constant speed, which is nearly, but not quite, equal to that of the generator. The electrical plant was constructed by the firm of Breguet, and at each lighting center a battery of accumulators is provided as a stand-by, and to supply current during the hours of light load. The efficiency of this arrangement is, of course, considerably lower than would be the case if the lighting were carried out on the alternate current transformer system. The two motors at the harbor station have at ¾ load an efficiency of 55 per cent. and at full load an efficiency of about 60 per cent. Taking the commercial efficiency of the generators to be 85 per cent., the commercial efficiency of the whole arrangement at ¾ load is about 44 per cent.

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